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THE EDITOR will be pleased to consider Literary Contributions dealing with subjects within the purview of this Magazine, and to make satisfactory arrangements with Contributors if MSS. be accepted for publication. High-class engravings from photos and drawings will be prepared free of cost to the writer

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Freedom Once More!

"For what avail the plough or sail,
Or land or life, if Freedom fail?"—EMERSON.

WITH politics we have no concern, but we may nevertheless heartily congratulate all who are, or will soon again be, inhabitants of the Transvaal, that corruption, injustice, and tyranny have been swept away, and that freedom under a just and honest government is to be their future lot. In expressing this sentiment we feel sure that we are giving voice to the feelings of Unionists and of all true Liberals alike, although there are doubtless some ultra-Liberals who object, or profess to object, to the emancipation of British subjects in South Africa.

People of the class in question may be honest in their protestations, or they may feel impelled to protest simply because the splendid work to which we refer has been done by their political opponents. It does not much matter in any case what may be the inner workings of their minds, for happily such persons have little influence in the land, and receive little sympathy, except from Continental newspapers. As the recent election has shown, the people of the United Kingdom have determined that the good work commenced shall be carried to a happy and successful consummation. What has been done in Egypt will now be done in South Africa. Chaos will be replaced by order, corruption by honesty, favouritism by equality, and slavery by freedom. Mining and other industries have been repressed, except so far as they may have been useful to provide funds for improper purposes and to enrich a few dishonest men who governed the country. Yet in spite of this state of things some measure of prosperity has been attained, and substantial progress has been made during recent years.

In 1887 the production of gold in the Transvaal was 23,125 ozs. In the year following 208,121 ozs. were produced, but we believe there are no reliable data showing the number of stamps working, or the tonnage crushed. The year 1888 was a remarkable one by reason of the wonderful output of the Robinson Company, for in the latter half of the year the ten-stamp mill of this company crushed no less than 3,952 tons, being an average of 658 tons per month, and the production of gold therefrom was 19,990 ozs., equal to 3,331 ozs., per month, the grade of the rock being rather more than 5 ozs. to the ton. Such a result as this probably constitutes a precedent in the records of gold-mining, and at the time it attracted considerable attention to the district in question. Interest was also stimulated by the successful operations of other companies, and a remarkable extension of mining operations was the natural result, as will be readily understood when we state that in the years 1889, 1890, and 1891 the gold production in the district was more than 1,630,000 ozs., and that at the close of 1891 there were 1,560 stamps in operation. The year 1892 was one of extreme importance in the history of the goldfields, for the reason that the cyanide process for the treatment of tailings and concentrates then came into general use, and the sorting out of waste rock was systematised during the same year. At the end of 1892 it is recorded that 1,979,354 tons of ore had been reduced by 2,530 stamps. From this large quantity of material there resulted 973,291 ozs. of mill bullion, and 200,526 ozs. of bullion from tailings and concentrates, which with 37,051 ozs. from the banks and other sources, gave a total output of 1,210,868 ozs., valued at £4,297,610. For the period commencing with the year 1893 and ending in May 1899, the quantity of ore reduced was 28,742,977 tons, yielding 17,531,562 ozs. of bullion, the value of which was £61,097,627, and at the last-mentioned date about 5,800 stamps were in operation. It will be noticed that a progressive increase in the number of stamps is evident throughout, but it ought also to be remarked that owing to the employment of heavier stamps during latter years, the duty per stamp has been raised from 3·21 tons in 1892 to 4·77 in 1899. So far as plant and machinery are concerned there have been large additions since the year 1893. At that period about 1,700 boilers were in use, of which about 730 were employed in the Johannesburg district, and the remainder were scattered in various parts of the Republic.

By the end of 1897 the number of boilers was 2,282, and of these 943 were in use on the Witwatersrand, Heidelberg and Klerksdorp goldfields. At about the same time 1,239 steam engines were in active operation, 946 of these being used in the Johannesburg district for the following purposes:—Winding, 314; pumping, 170; crushing, 113; air-compressing, 117; lighting, 58; power transmission, 58; traction, 7; various purposes, 134. Electrical plant was represented by 280 dynamos in the Johannesburg district alone, furnishing light and power equal to 13,853,625 watts to 1,408 motors and 32,971 lamps having 790,622 total candle-power. In 1897, 33,868 cases of dynamite, costing over £150,000, and 139,286 cases of blasting gelatine, costing more than £740,000, were required for breaking the ore mined on the Witwatersrand Gold Fields. In addition to the expenditure of about £890,000 for these explosives, £56,000 was spent in fuses and detonators. As our readers are aware, the dynamite industry was one of those things which was not worked entirely on free trade principles, and although the dynamite factory was equipped with the plant and appliances necessary for the production of high explosives in every way suited to modern requirements, the prices charged were never regarded with much favour by buyers. Fully 8,500 whites and 60,000 natives found employment on the fields in 1897, as compared with 3,500 whites and 30,000 natives during the year 1893. Similarly the total value of machinery and plant on the same fields at the end of 1897 was £6,355,037, as against about £2,000,000 in 1893.

These figures are sufficient proof of the fact that the position attained by the late Republic has been very largely due to the energy with which its resources have been exploited by the hated and despised "Outlanders."

It is, or perhaps we should now say was, the fashion amongst certain people to pretend that the simple and pastoral Boer did not wish to have the resources of his country developed, and that wicked and worldly gold-miners had no right to intrude upon that Arcadian land. Those who are better informed know perfectly well that the late President directly invited the exploitation of the goldfields, for he saw in them a ready and easy means of procuring money both for government purposes and for the more comfortable lining of his own private money chest. A favourite reproach, again, is that capitalists have been the curse of South Africa. We admit that one or two such, whose star is no longer in the ascendant, may have fulfilled this rôle most admirably, but it is absurd to speak ill of those who have filled the country with skilled engineers, who have covered mine after mine with the most perfect machinery in the world, and who have brought prosperity to thousands of their fellow-men.

Gold-mining is not the only important industry in South Africa which has received benefit from enterprising capitalists. Progress in the Transvaal has been almost entirely, though indirectly, due to the same class. During the last 30 years the trade of the country has increased tenfold, railways have sprung up, and the exports a year or so back were about £5,000,000 per annum, apart from gold. The use of electricity has grown amazingly; Johannesburg is probably unique as being one of the few cities deriving light from a source of power situated at a distance of some 24 miles. If the modern engineer has not hitherto assisted the Boer farmer it is the fault of the latter, who is nothing if not superlatively conservative. But something has been done in the way of agricultural development. Taking one case as an illustration, we may refer to the extensive series of industrial ventures commenced within recent times by the Vereeniging Estates, Ltd., at Vereeniging and Viljoen's Drift. In addition to two collieries, one on each side of the Vaal River, and constituting one of the largest coal-mining schemes in South Africa, there are, or were, a large and well-equipped brick and tile factory, an extensive grain-growing and general agricultural undertaking with a complete milling plant, and a large stock-breeding establishment. The Estates include some 22 farms, covering over 130,000 acres. A portion of the property is within the Vaal River Colony,

but the greater part is in the Orange River Colony. The agricultural estate was equipped with the most modern steam ploughs, threshers, winnowers, and other machinery for the cultivation of 15,000 acres reclaimed from the bare veldt. About 600 acres on the south bank of the river were under irrigation, a system which was being largely extended at the outbreak of the recent rebellion.

In the forestry section there are some 600,000 oak trees, some of these being 20 ft. high at an age of a little more than four years. Altogether 3½ million trees are included in this department, a large number being pines of various kinds. The stock-breeding establishment was devoted largely to mules, although cattle-raising and horse-breeding had not been overlooked. Fruit-growing is also likely to become a feature of the estate, and a number of orchards have already been planted.

As the line, formerly known as the Orange Free State Railway, depends entirely on the collieries of the estate for fuel, it is only natural that the coal-mining department should form a most valuable part of the company's operations. In addition, we believe that the Cape Government Railway and the De Beers Company are also large buyers. Coal-mining is conducted at two points, each connected with the railway system.

The Vereeniging Colliery was equipped with plant capable of an output of considerably over 20,000 tons per month, and the Cornelia Colliery, in 1899, had a temporary plant with an output of 5,000 tons per month. A new shaft was then in course of construction, and an equipment was designed on the basis of 30,000 tons of large coal per month. On the south bank of the Vaal the area of coal available has been roughly defined as of some 35,000 acres in extent, the seam varying from 9½ ft. to 23 ft. in thickness.

Electric coal drills made by the Jeffrey Manufacturing Company, of Columbus, U.S.A., have already been introduced into the collieries, and we learn that this American firm, having thus, we regret to say, forestalled our own manufacturers, has also managed to secure a permanent agent in the country.

As an example of engineering enterprise in another direction, we may refer to the Rand Central Electric Works, Brakpan. Although the scheme to which this establishment owes its origin was due to two Englishmen, the contract for the whole of the plant was secured by Messrs. Siemens & Halske. The eight boilers are of the Steinmueller multitubular type, each of 600 i.h.p.; the four engines, each of 1,000 b.h.p., are of the triple-expansion vertical type. by the Saechssche Maschinen Fabrik; whilst the dynamos, transformers, and other electrical plant are by Siemens & Halske. Possibly the shareholders of this concern have not had much reason for congratulation in recent times, but there can be no doubt whatever that future prosperity is in store for them.

One of the least satisfactory circumstances connected with this and other enterprises in South Africa is the fact that foreign firms have been too much in evidence to please those who have the interests of British industries at heart. Probably other nations have been unduly favoured in the past, but there are evidences that a good deal of their success is to be attributed to greater activity and superior commercial organisation.

The few examples of industrial undertakings which we have mentioned serve to indicate the immense possibilities of the territories which have again come within our control. Under an enlightened administration no restrictions will be placed upon the work of development. Capital will flow into the country, mining operations will be resumed and extended, agricultural pursuits will be followed on modern lines, immigration, no longer checked, will bring thousands of new inhabitants; whilst homesteads, villages, towns, and cities will spring up and grow to maturity.

These will bring in their wake increasing local trade and the demand for additional traffic facilities, as well as for manufactured products in infinite variety.

Already we hear that foreign firms are on the alert, and are preparing to meet the expected demand; but very little evidence is forthcoming to show that British firms have yet appreciated the position.

Freedom has now come to South Africa, and no one doubts that all her colonies, old and new, are about to enter, though perhaps not immediately, upon a time of unparalleled prosperity and progress, in which it is our hope that the mother country may fully participate.

Technical Education for India.

THE importance of technical education is being more and more realized in all civilized countries, for the highest achievements during the closing century, or, at all events, those that have left their deepest impress upon its character, have been achievements in the field of applied scientific knowledge. Victory in this special field has become a surer means of national supremacy than victory in the battlefield; nay, victory in the battlefield itself depends now-a-days to a very great extent on mastery in the mechanical arts, and we cannot be astonished, therefore, at the rivalry of the various countries in trying to obtain the foremost rank among those who are in possession of useful technical knowledge. There is considerable diversity of opinion, however, as regards the best means for promoting the acquisition of such knowledge, some laying the greatest stress upon mental training, while others emphasise the importance of manual skill. Both, of course, are right to a certain extent, but only those are entirely right who have found the *juste milieu*, which, however, cannot be determined for all places and people alike, and is greatly influenced by local and individual differences. But, taking it all in all, it cannot be denied that in the colleges of Great Britain at least, until quite recently, manual training has been rather neglected in favour of mental education and theoretical teaching, and this also appears to have been the case in India, to judge from a very interesting lecture recently delivered by Mr. John Wallace, the editor of the *Indian Textile Journal* and the *Indian Import and Export Trades Journal*, at the Jamsetjee Nussarwanjee Petit Institute at Bombay, which, under the title of "Technical Education for India," has been published as a special pamphlet by the Indian Textile Journal Co., Ltd., Bombay. In this lecture the author points out that there are many and infallible symptoms showing that manual skill in India is slowly but steadily decreasing, that native labour is becoming more and more unfit to hold its own against countries which import their products into India, and that a radical change in popular education is necessary if this tendency toward absolute incapacity is to be arrested in time.

Mr. Wallace concisely characterises the situation as follows: "While the Indian artisan is heedlessly degrading his craft, an extraordinary industrial activity may be observed in other countries which are in close commercial relation with this. In exchange for the raw produce of India these countries send back manufactured goods by the shipload, and these goods, thanks to the absence of protection duties, enter into disastrous conflict with the industrial products of India. Many of the imported articles are made by men whose day's pay would maintain the Indian for a month, and yet the latter cannot compete for the simple reason that he does not know the *art*. If he had only half the technical knowledge of the European, his situation would be greatly improved, but he is averse to study, impatient under discipline, and as soon as he can earn enough to meet the simple immediate needs of his family he considers his education at an end."

In what follows, Mr. Wallace attributes this sad state of affairs to an erroneous system of education; but it seems to us that the defects in the character of the natives, enumerated in the last sentence just quoted, fully suffice to explain the inability of the Indian labourer to hold his own against the competition of the workmen of Great Britain, for instance, who are made of sterner stuff, and, with all their faults, have sufficient ambition to strain every nerve in the rivalry with other civilized nations. We do not wish to pass judgment upon the modern Hindoo, but, if we accept Mr. Wallace's

description of him as correct—and we see no reason for refusing to do so—the symptoms described indicate that inferiority of race which is the cause of the disappearance of many a native people when they come in conflict with the Anglo-Saxon or other more virile races. Mr. Wallace, however, seems, as above said, to attribute the gradual decadence of the native arts to a faulty system of government education. He objects to the plan hitherto pursued for the purpose of developing industrial enterprise in India, namely, that of training a small number of young men in the physical sciences, and points out that the so-called young engineers coming out of the Indian colleges are not craftsmen, that in fact they have acquired no practical skill whatsoever, "have very often a hazy notion of the direction in which a screw turns, cannot close a rivet or direct the operations of a smith or carpenter, or give a practical opinion regarding the qualities of iron or timber." Well, to state the truth, we hardly need to go to far-off India to find examples of these negative results of a so-called "technical" education, and could mention many instances in which young gentlemen, after having passed through an arduous course of lower and higher mathematics, of physical science, of chemistry, of mechanics and the other usual subjects of the curriculum, would find themselves absolutely nonplussed were they asked to perform the simplest task in a workshop. Of course, there is a considerable improvement noticeable of late years in the technical education of the British youth, and such men as Professor Perry, for instance, as his admirable lectures on mathematics show, are doing excellent service in weeding out from the programmes of our technical schools the useless theoretical rubbish which serves no other purpose than to enable the student to make an outward show of scientific knowledge which but thinly veils his real ignorance. Still, the fact remains that a very large percentage of our students, exactly as, according to Mr. Wallace, is the case in India, after leaving college have acquired but little that is of real use to them in practical pursuits; and that much of their training has made manual labour distasteful to them, is a fact that few who have come in contact with college-bred craftsmen will dispute. As many well-informed engineers in Great Britain, so also Mr. Wallace in India, believes the remedy for this condition of affairs to lie in the substitution of manual training for useless branches of instruction, and in the limitation of education to subjects that will be of real use in the future life of the pupils. Mr. Wallace, however, goes further, for he desires that, as regards the education of the native labourers, the instruction in reading and writing, hitherto required as a basis, should be entirely abandoned, and that the pupils should be taught orally, and by the eye, the principles of some craft, together with the manipulation of the tools and the art of taking care of them. For this purpose he advises the establishment of normal schools, in which the teachers are to be young men of not less than twenty years, who have shown evidence of ability and intelligence in their trade, and who have the gift of teaching others. In order to support his proposal of the suspension of the lessons in reading and writing, for which he thinks the majority of the natives "has no use," he remarks that the industrial progress in Europe shows that "the arts of labour reached a very high development long before reading and writing became a necessary accomplishment among the industrial classes." We do not think, however, that this is a strong argument in support of the author's plea that the training of the young craftsmen should be illiterate. Although it is true that European workmen in former ages became proficient in their craft without even an elementary literary education, that is no proof that they would not have advanced much faster had they been better instructed as children; and what Mr. Wallace seems to forget is, that our young artisans until the most recent times had to pass through many years of apprenticeship, during which they were rendered proficient by constant practice under close supervision, which is a very different matter from acquiring manual skill in a

comparatively limited course of education in a "normal school," where the teacher has to divide his attention between a great number of pupils, unlike the "master" in former times, who had to deal with one or two apprentices only, whose work he supervised day after day during the whole period of apprenticeship. Both the limitation of instruction to a course of school education, and its unavoidable curtailment on account of the necessity of dealing with a great number of disciples simultaneously, require, in order to be efficient, a better preliminary education for the pupil than was necessary under the old system. We fully endorse the author's view as regards the superiority of manual training over useless theoretical teaching, where proficiency in one of the crafts is aimed at; but we fear that if Mr. Wallace's above-quoted description of the character of the natives is true, and if they, as he says, are too indolent to desire to earn more than is absolutely required to keep them and their families from starvation, while, moreover, they are unwilling to submit to any kind of discipline, no reform of the system of education will protect them against ultimately succumbing in the struggle for existence with more manly races.

Glasgow International Exhibition, 1901.

TWELVE years ago Glasgow held its first International Exhibition, and in May, 1901, it will throw open the doors of its second. Considering the magnificent results that followed the Exhibition of 1888—the financial surplus alone amounted to £54,000—Glasgow cannot be accused of undue haste in organising another, and from what is already known the exhibition of next year promises to excel in size, in importance, in general attractiveness, and more particularly in scientific interest, its well-remembered predecessor. All the elements necessary for the successful carrying out of the vast undertaking are present. The shrewd commercial men in whom the management is vested have been honoured with the patronage of Her Majesty the Queen and His Royal Highness the Prince of Wales; they have the active encouragement of the Corporation of the "Second City;" the personal assistance of those learned in the Arts and Sciences; the co-operation of many of the principal scientific societies; and they have—not the least important detail—a guarantee fund exceeding half a million sterling behind them.

The Exhibition, as in 1888, will be held in Kelvingrove Park, a site of exceptional beauty and convenience, extending altogether to 67 acres, having been granted by the Corporation. Out of a number of designs submitted to the executive, the one prepared by Mr. James Miller, I.A., Glasgow, was accepted, and the first sod was cut by the then Lord Provost, Sir David Richmond, on April 22, 1899. The buildings will be divided into four main groups—the fine art galleries, the general industrial section, the machinery hall, and the grand hall for entertainments. The industrial section will be 700 ft. long, 360 ft. wide, and surmounted by a grand dome. Through the centre of the section will run the main avenue, 92 ft. wide 150 ft. high, with a circular arched roof—one unbroken area (save for the roof standards), which gives expanse to the interior and allows exhibits to be arranged in any way desired. The great dome, which will be the leading feature of the structure, will be 80 ft. in diameter, and there will be four white towers rising to a height of about 180 ft. above the level of the ground. Round the dome, at a height of 100 ft. from the ground, will run a huge balcony which will be used as a promenade. Each corner of the building, as well as the north and south fronts towards the centre, will bear a pavilion, about 35 ft. sq., topped with minarets at the angles and terminating in domical roofs. The style is Spanish Renaissance, one which contributes to brightness and gaiety of colour.

The Machinery Hall, which is being erected upon ground to the south of the main section and across the main east and west city thoroughfare, will be connected with the main section by means of an overhead bridge across the street at

such a height as to enable the electric tram cars to pass underneath. The building is 500 ft. long, 320 ft. broad, and consists of one central bay, 100 ft. wide, and four bays each 53 ft. wide, the height of the central span being 41 ft. and of the side spans 29 ft. An overhead gallery, 15 ft. wide, on each side of the central bay will enable visitors to get a bird's-eye view of the whole of the exhibits. A railway line for goods and a footway for passengers is to be run into the hall, which, along with the boiler house and goods yard, will cover about 5½ acres; and altogether the entire buildings, including the magnificent new Art Galleries, which are to be the future home of the Corporation's treasures, will extend to almost 20 acres. Owing to the great demand for steel and iron some delay occurred in the building, and it was found necessary to cut out a large proportion of the steel, so as to facilitate the work of erection. No further delay has occurred however.

As to the scope of the Exhibition, the executive started with the idea of presenting a full illustration of the produce and manufactures of the British Empire, its dependencies, dominions, and colonies, and an adequate representation from other countries. France, Russia, Austria, Japan, Persia, Morocco, India, America, Canada, Queensland, West Australia, and British South Africa have promised to support the Exhibition. The exhibits will be divided into eight classes. The first will be devoted to raw material—agricultural and mining—and the second to industrial design and manufacture, a branch which the Executive are desirous of making as complete and representative as possible, and with this object deputations from the council have visited the leading centres with the object of soliciting support from the principal manufacturers. One of the most important sections is the third, which embraces machinery, motive power, electricity, and labour-saving appliances in motion. A very strong committee is in charge of this department, and it is intended to make it one of the outstanding features of the Exhibition. Preference is to be given to machinery in motion, and everything that can be done to assist exhibitors will be carefully performed. A special feature will be the driving of exhibits by electric motors. Of marine engineering and shipbuilding there will be a notable display, as befits the city which has been so closely associated with these branches of industry. One exhibit will be a collection of selected models showing the progress made during the century—from wood to iron and steel, from sail to steam, from paddle to screw, and from single to triple-expansion engines. In the locomotion and transport section will be shown, amongst other exhibits, the latest patterns of railway engines alongside the smartest and swiftest motor-cars of home and foreign manufacture. Classes will also be reserved for science and scientific instruments, education and music, and sport and sporting appliances. A special section is allotted to women; and the fine art, history, and archæology section, which will be housed in the new galleries now being erected at a cost of a quarter of a million, promises to be one of the most popular "show" places in the grounds.

The contractors for the Exhibition buildings are Messrs. William Shaw and Sons, whose offer of £68,425 was the lowest, and in addition the Grand Hall will cost some £16,000. With other buildings in the grounds the total cost, apart from the Art Galleries, will exceed £130,000.

The whole of the engineering work, lighting, etc., is being carried out under the supervision of the Exhibition engineer and electrician, Mr. Thomas Young, the architect, Mr. Miller, attending to the other departments.

Of the music, entertainments, and special indoor and outdoor attractions, it is unnecessary to write here. A few lines, however, must be given to scientific meetings to be held in connection with the Exhibition. First in age, dignity, and general importance comes the meeting of the British Association, of which Professor Rucker, the eminent authority on terrestrial magnetism, is to be President. The Institute of Mechanical Engineers, the Society of Chemical Industries, and the Society of Engineers and Ship-builders, have all arranged to visit Glasgow; and

very likely additions will ere long be made to this list. In little less than a year, Kelvingrove Park, with its vast array of art and industry, its own postal and telegraphic offices, banking and other facilities, and with its own railway service, will become a centre of industry, amusement and education; with all attached to it working to repeat, indeed to excel, the achievements of ten years ago; for the surplus now, as then, is to be applied to the promotion of Art and Science, which means, in brief, the good of mankind.

Swazieland the Neglected.

THERE has recently been published an exceedingly interesting *brochure* from the pen of Mr. Allister M. Miller, who is the manager of the Corporation in Swazieland, which, with the exception of certain articles that appeared in the *Times of Swazieland* in 1897, is the first history of the country that has appeared in print. Hitherto commercial companies have exercised a powerful influence over the land, and have, so far as they were able, guided the course of events. They would have been even more influential but for the cession of Swazieland to the South African Republic in 1894 by virtue of an agreement entered into between the British Government represented by Sir Henry Loch and the Executive of the Republic. This agreement was the result of voluminous correspondence and long negotiations between Downing Street and Pretoria. At the time, there is little doubt that President Kruger imagined he had done a "slim" thing in thus extending the authority of the Republic so much nearer to the sea and incidentally acquiring a rich territory. But when the Boers had got tired of gazing at their flag flying over the Court House at Bremersdorp, and began to investigate matters, they soon discovered that almost everything worth having in the country, particularly "concessions," already belonged to Englishmen. And when, later, the British Government annexed Zambaana's and Umbegisa's territory—lying south-east of Swazieland between that country and the sea—the Transvaal officials wildly denounced the British, declared the country was no longer of any use to them, and adopted an attitude of hostility to the English colony which was maintained with varying virulence up to the outbreak of the war now slowly drawing to a close.

Politics and trade have been inextricably mixed in Swazieland ever since the beginning of things—ever since, in the years 1886–89, a few white men, some residents, and some visitors, secured from King Umbandine certain rights and privileges which were called concessions. Most of these concessions were for mining purposes, inasmuch as a large portion of the country is highly mineralised. The configuration of the land is, indeed, very remarkable. The western portion of the country is extremely mountainous, and there, gold, tin, and coal exist in quantities. On the other hand, the eastern side of Swazieland is plain and rolling country, adapted in some parts for stock raising and in others for plantations. Over a large area the soil is exceedingly rich, and resembles some of the most fertile districts of Natal. Here there is a country which possesses in a most marked degree those attractions for immigrants which have drawn the Anglo-Saxon race to every quarter of the globe. At present the gold mining has not been brilliantly successful. A respectable output has been effected, for the value of the gold won from the first beginnings up to the autumn of last year was about £350,000; but it appears to have cost as much to get it as it was worth. When it is considered that the rate of transport on development machinery has sometimes been as high as 25s. per cwt. it would be surprising if much better results were achieved. When the Transvaalers came into possession, the white colony in Swazieland were led to believe that great things would be done in the way of opening up the country. Particularly was it expected that railways

would be made. The Dutch came, but they made no railway, and the state of political unrest which followed prevented any large scheme being undertaken as a private venture. No Boer capital was forthcoming, and British capital was shy. Notwithstanding the unfavourable conditions which prevailed, the English managed to jog along and even make some progress. Confident in the resources of the country, and hopefully looking forward to a good time coming—sooner or later—the English miners and traders quietly made the best of their position, animated by that sturdy optimism which has always been characteristic of the race. A Chamber of Commerce and Industry was instituted, a newspaper was started under the auspices of the Printing and Government Gazette Concession, and the Swazieland Corporation went on quietly surveying its properties and noting the capabilities of the land.

What, then, is the mining outlook in Swazieland at the present moment? That gold is there in payable stone there can be no doubt. Also, the tin already produced, in primitive fashion, has fetched a high price in the London market. Then there is a valuable mineral—scheelite—and there are large bi-anthracitic coal deposits which are being proved in the sandstone belts to the east of Bremersdorp, the principal town. The Swazie-schists, a highly auriferous formation, cover 250 sq. miles of territory, containing many promising reefs. This territory is held on lease by eight companies all paying rent to the Government. At present nothing is being done for the reason that life and property in Swazieland at the present time has a precarious existence, and something like absolute anarchy prevails. Presently we shall change all that. The neglected Boer Protectorate will be converted into a British Colony; and the mining companies, eager enough to resume operations, will have little difficulty in procuring labour and the necessary white *personnel*. When the time comes for the English administration to put the Swazie house in order, one of the first things to be considered will be the construction of a railway through the country, with an outlet at Delagoa Bay. It will not be the easiest of undertakings, for the mining country which will have to be served is in the mountains. Swazieland may be compared to a large-sized Wales without a sea-board, and with a broad strip of comparatively low country included in its eastern boundary. But there is an obvious route for the much-needed line of rails, which would traverse the fertile plains and gentle hills of the east, and without any sensational gradients would climb into the western mountains. Given such a railway and good government, there is absolutely no reason why Swazieland should not become one of the most flourishing and populous colonies under the British Crown.

In Mr. Miller's history great emphasis is laid upon the numerous monopolies in possession of his company. The possibility of these privileges being exploited with too great an insistence is one of the little drawbacks which we hope will not interfere with healthy development. But if the establishment of British authority is accompanied by a common-sense revision of the *status quo ante* there should be no difficulty in securing fair-play to new comers without any injustice to the present concessionaires.

An Independent Platform.

Our general policy by this time is so well known in industrial circles throughout the length and breadth of the land and in countries abroad that it is scarcely necessary to dilate further upon it. There are some who *purposely* misunderstand it. They can keep on doing it, for, though we do not need free advertising, we do not mind it in the least. Was there ever a successful project that did not beget enemies and imitators? It is sufficient for us to know that such a degree of appreciation has been meted out to this journal that in the shortest space of time on record we have attained the largest sale circulation of any engineering monthly

in the world. Our current issue of *over* ten thousand copies is eloquent justification of our existence and pretensions, and should silence any carping critics.

But we would like to have a few words with our readers on another point.

It has been pointed out to us on occasion that although the very handsome illustrations with which this magazine is embellished — all made at our own expense — reflect a considerable amount of credit on the proprietors of this publication, undue prominence appears to have been given to certain firms or corporations, and the inference is that the articles accompanying such and such illustrations may possibly be paid for by the firms whose specialities are noticed, or that such and such matter is issued on the basis of an advertisement contract. We do not know how many of the thousands of thoughtful men who periodically read this Magazine hold this view—we will not insult the intelligence of the majority by suggesting it—but there may be a few, and we want to at once dissipate the illusion where it possibly exists. It always has been and always will be our desire and intention to insert nothing in the literary columns of this Magazine but absolutely independent articles. Nothing that savours of a "puff" or a "write up" is admitted. We are not responsible for the opinions of our distinguished contributors, and we describe nothing in the way of machinery or appliances except on their pure merits, whether business hangs on it for us or not, or whether we unfortunately offend competitors in the same line. As to our leaders and editorials, they are as free from bias as it is humanly possible to make them. We are here to state facts, and to issue intelligent technical descriptions and criticisms of machinery and engineering achievements, and recognizing that scientific progress is cosmopolitan we should be failing in our duty to the British engineer and manufacturer did we not notice the products of nations other than our own. We endeavour to secure and publish the best information possible as to the specialities and doings of foreign engineers and manufacturers for obvious reasons. This, there is no gainsaying, constitutes a first-class advertisement to the firms in question, but we cannot help that. We present the matter of necessity. It is for our manufacturers to read, mark, learn, and inwardly digest — and *improve*.

We may be pardoned for making a passing reference to our advertisement pages at this juncture, as the same affect our policy in this connection and concern our chief supporters. FEILDEN'S MAGAZINE is the only engineering publication in Great Britain, or elsewhere, which, whilst it has secured a great number of esteemed foreign readers, declines to admit foreign announcements in its advertisement pages. This journal is, in so far as its trade policy is concerned, simply and solely designed to push British trade and to maintain and increase British commercial supremacy ; and whilst we are ready to show in our literary columns what firms other than British are doing, and shall naturally do all in our power editorially to foster and encourage friendly relations, as much for business as for other sensible reasons, we simply say we cannot sell our editorial space for "puff" purposes any more than we can sell our advertising pages to push foreign-made products.

The only possible deviation from this is in the case of firms who may be domiciled both in this country and in the United States—that is to say, firms which employ British labour and capital. This needs no further explanation.

We sincerely and confidently hope that our reasons will not be misinterpreted on either side of the water. We know that our policy has not made us any enemies among those whose opinions we value, and the solid appearance, and may we be pardoned for saying, the acknowledged worth of the Magazine to-day, is monumental evidence that we are on the right track.

"We are, in the vastness of our possessions, losing our grip on national sentiment. It is our duty to maintain intact, and to defend by sea and land, all that our empire builders have left us. The day that sees the defence of the British Empire sapped, sees the disintegration of the Nation's trade and the hands of civilization's timepiece put back 200 years."—Rt. Hon. Lord Charles Beresford, C.B.

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British Manufacturers and South Africa . . .

Our contemporary the *Daily Express* has done a service by calling attention to the industrial situation in South Africa, and pointing out the danger of British manufacturers being supplanted in their own market.

We beg to point out, however, that Feilden's Magazine foresaw this danger more than nine months ago. In March of this year in fact, we said in our first leading article:—

"When the war is ended, . . . what is to be the commercial position in it of the country which has made such exertions and borne such sacrifices? Is South Africa to become the happy hunting-ground of our trade rivals? America and Germany are like hounds straining at the leash, waiting impatiently till we have done the work, to pour their capital and their manufactures into the land we shall have thrown open to their enterprises:—. . . England and the British Colonies are making heavy sacrifices and incurring the gravest risks in their determination to secure for British subjects their legitimate political rights in the South African Continent. For this object, sacrifices are made in a willing spirit; but we think the citizens of the British Empire did not contemplate, as a necessary part of their programme, the clearing of the way at so much cost of blood and treasure for their commercial rivals."

From the foregoing it will be seen that however justly the reference of the *Daily Express* to the indifference shown by the "regular engineering organs" to "a matter of such moment to the engineering industries of the country" may apply to the bulk of our technical contemporaries, the reproach cannot touch Feilden's Magazine.

From the beginning we have been aware of the efforts being made by Germany and the United States, more especially the latter, to secure a permanent footing for their exported manufactures in the Transvaal to the prejudice of English industry, and have repeatedly warned our manufacturers of the serious nature of the competition which, at the conclusion of hostilities, they would find directed against them.

That the sensational statements appearing in the newspaper press are exaggerated is probable; but of their substantial foundation there can be no question. It is true that the Under-Secretary of State for War has caused a semi-denial to be published stating that British merchants have no cause for apprehension. It is difficult to see, however, what particula authority can be possessed by the Under-Secretary for War for making such a declaration, which, it is to be noted, is directly opposed to known and stated facts. If further evidence than that already published were required to convince English manufacturers of the precarious nature of their commercial hold of the two countries now brought under British rule, it will be found in the incessant reports to the U.S. Government of Consul-General James G. Stowe, of Cape Town, from which it appears without question that a carefully-organised scheme has long been in preparation to secure the Transvaal as practically an American market.

"English goods for English markets," says FEILDEN'S MAGAZINE, a saying that should be voiced and acted on by every patriotic citizen of the British Empire. The English people do not pay taxes to develop countries for the benefit of their commercial rivals; those who pay for cultivation are entitled to receive the harvest.

Let us, then, make up our minds that South Africa is to be a British market, and not a dumping ground for the superfluous products of our highly protected trade rivals. As both the conquered States will presumably occupy the position of Crown Colonies, and, in consequence, will be directly under the control of the British Government, we look to the British Government that these territories shall not be alienated from British commerce in even the slightest degree.

Explosives in Coal Mines . . .

DURING the course of last month a new order was issued by the Home Secretary, under Section 6 of the Coal Mines Regulation Act, 1896, with regard to the use of explosives in mines. It appears that the chief purpose of the order in question is to embody the results of the special test for explosives, the establishment of which was announced in a Memorandum dated October 18th, 1899. For some time past there has been a very general agreement on the part of mine-owners as to the desirability of further assistance in the selection of explosives than has hitherto been afforded by the previously existing "permitted list." That list merely mentioned the names of such explosives as had passed the Woolwich test, and it in no way differentiated those substances which just succeeded in struggling through the test from those which might be fired safely under much more stringent conditions. In consequence of reports from the mine inspectors to the effect that coal-owners would welcome any further recommendations with regard to this important matter, the Secretary of State decided to establish the still more severe test mentioned above, and which may be described as the "special test," to distinguish it from the ordinary, or Woolwich, test. All explosives which succeed in passing this trial are to be placed on a separate list, to be termed the "Special List of Permitted Explosives."

The special test differs from the ordinary test (1) in the amount of the charges, which is increased by half for the first ten shots, and doubled with a slight increase of stemming for the remainder; (2) in the more sensitive character of the gaseous mixture in which the shots are fired; and (3) in the fact that while an explosive might pass the ordinary test with two failures in 40 shots, under the special test a single failure disqualifies. Six explosives have now passed the special test, and have been placed on the "special list," which forms the first schedule to the new order. The list of permitted explosives which have not been placed on the "special list" forms the second schedule. It should be remarked that in the case of the explosives which have been included in the schedule, the existing definitions, as they appear in the orders now repealed, have been retained on the ordinary list of permitted explosives; but the retention will merely be temporary, and is for the purpose of enabling coal-owners and others to use up their existing stocks of explosive material. Although the establishment of the "special list" should furnish definite assistance to mine-owners in the selection of explosives for use under dangerous conditions, it must be remembered that responsibility still attaches to the owner as to the choice of the safest explosives and of those best suited to the requirements of any particular mine. The owner will also, as before, be responsible for the establishment of all reasonable safeguards for the purpose of keeping the material in good condition, and of ensuring its proper use.

Whilst the actual number of deaths does not in itself furnish a true criterion as to the comparative danger or safety of the coal-mining industry, we are pleased to observe that in mines under the Coal Mines Act the death-rate for last year was only 1·26 per 1,000 persons employed. This is the lowest rate hitherto recorded, and it is highly satisfactory to find that the improvement which was evidenced in 1895 has been consistently maintained.

Indian Geological Survey . . .

A REPORT recently issued by the Government of India on the work of the Geological Survey for the year 1899-1900, contains a large quantity of matter, the greater part of which relates to purely scientific investigation. There is, however, a special section dealing with economic geology, which possesses more interest for busy men who have little time for abstruse considerations. Amongst other enquiries, the director of the survey has attempted to ascertain to what extent it would be practicable to increase the water supplies in certain parts of the Indian Empire by means of artesian wells. The suggestion has been made at various times that the Government has failed in its duties by neglecting to resort more frequently to this means of supply. Such criticism is not altogether founded upon fact, for, as the director states, an immense mass of official papers prove that constant efforts have been made to augment the water supply by means of artesian borings. Few of these attempts have been attended with even moderate success, except in the Quetta district. As a matter of fact, the necessary conditions appear to be conspicuously absent in the great Indo-Gangetic plains, and in the peninsula proper. In Rajputana, Gujarat, and Sind, the prospects of obtaining water by artesian well-sinking are much more favourable. Even in the recent drought water was readily obtainable in the extensive plains of Gujarat, where natives, on sinking a number of wells, found water of fair quality within 40 or 50 ft. from the surface. Experiments are still in progress for the purpose of acquiring more information as to this question, whose importance cannot be over-estimated. We are too frequently reminded by Famine Funds of the terrible sufferings which are entailed by scarcity of water in India, and shareholders in industrial undertakings are also reminded by reduced dividends that commercial prosperity is considerably affected by the same condition.

Examinations have further been conducted by the Geological Survey, in accordance with a decision that full reports should be drawn up as to the mode of occurrence and the nature of auriferous rocks in the most important localities. Up to the present, very little encouragement is to be drawn from the report of the year 1899-1900. The Wuntho district of Burma is found to exhibit fairly numerous reefs, containing gold in paying quantities, although it is doubtful whether there is sufficient ore to ensure commercial success; and the reefs of South and South-east Wynard are not much more promising.

Mr. Manuel on Propeller Shafts . . .

THERE was an interesting discussion at a recent gathering of the Institute of Marine Engineers on propeller shafts, which was greatly enhanced by the presence of Mr. Manuel, the superintending engineer of the Peninsular and Oriental Steamship Company. His experience in connection with propeller shafts he freely gave to the Institute, and he has promised to set his ideas out in a paper and hand it over to the Institute. Mr. Manuel has had trouble with propeller shafts, and, without ostentatiously publishing his results, has tried every kind of metal, from ordinary iron to nickel steel, and naturally knows the good and bad qualities of each. Of the theories of corrosion, which are year after year brought before and discussed by the Institute of Naval Architects, Mr. Manuel did not express an opinion; but he gave some practical results which he had obtained when subjecting the different metals to a fatigue test of his own. The different metals which he subjected to the tests gave the comparative results below :—

Ordinary iron ...	7	Ordinary steel	35
Best iron ...	15	Mild best steel	80

Under the ordinary rules these are looked on as equal, but under the fatigue test of Mr. Manuel they have the above values. Under ordinary circumstances a shaft, say of ordinary iron, would be taken out after it had made a certain number of revolutions; but the question remained as to what would be the extension of life of a shaft with the increased number of revolutions which shafts made of metal of the higher test

value could be expected to make? On account of the position which Mr. Manuel holds it is expected that he takes a great interest in the subject of propeller shafts, and that he does everything in his power to produce a better state of things than now obtains, but he had to confess that this expected state had not yet arrived. At the present time things are even worse than they were. But this was not so in his own Company. He read a paper on the subject 11 years ago before the Institute, and also an extended paper of further experience which he had with shafts before the Imperial Institute during the Jubilee year. He gave good advice in those papers, but he found difficulties were encountered in taking advice which should not occur. Most of the difficulties raised against adopting measures for preventing the corrosion and breakage of shafts were due to the opposition of trade and other interests. He did not think there was any necessity for such records of broken shafts as appeared, and he had no such record. He took every precaution against accidents. The nickel steel he had subjected to tests, and these had not convinced him, especially bearing in mind its higher cost, that it was preferable to good mild steel. Mild steel had been used for the construction of the propeller shafts of the ships of the P. & O. Company since 1881, and there had not been a single case of a broken shaft from that date to this. That was his experience. Nickel steel, on the whole, was stronger than mild steel, but only a very little. This little extra strength had induced the Germans and Russians to adopt it. But he did not think it was necessary.

Ne sutor supra crepidam . . .

THERE can be no doubt regarding the versatility of our transatlantic cousins; and most of them have more strings to their bow than one. In fact, they must have the gift of succeeding in more than one calling, owing to the instability of positions in their country; otherwise they would have but little chance of continuous occupation. Still, it is rather startling to meet with a legal light illuminating the darkness of the popular intellect with reference to scientific merit. Such a *rara avis*, however, to change the metaphor, has displayed his plumage recently in the United States District Court at Newhaven, Conn., where a case was to be decided relating to three inventions of Mr. Nikola Tesla — one of an electric magnetic motor, another dealing with the electrical transmission of power, and the third having reference to the specific construction of a motor embodying the invention of the other two patents; the main point being that there is not the waste of electric energy that there was under the old arrangement. The defendants were the New England Granite Company and others, who, as alleged, were using Tesla's inventions in mining and other operations. Judge Townsend, to whose gift of flight—poetical flight—we allude, in speaking of him as the rare bird among jurisprudents, upheld the plaintiff's claims, and we have no doubt that in doing so he was wisely inspired, but his rhetorical rhapsody is not likely to add to the weight of his decision. Here are his words: "A careful study of the evidence shows that Tesla has made a brilliant discovery. It remained to the genius of Tesla to capture the unruly, unrestrained and hitherto opposing elements in the field of nature and art, and to harness them to draw the machines of man. It was he who first showed how to transform the toy of Arago into an engine of power; the laboratory experiment of Bailey into a practically successful motor; the indicator into a driver. He first conceived the idea that the very impediments of reversal in direction, the contradictions of alternatives might be transformed into power, producing rotations, a whirling field of force. What others looked upon as only invincible barriers, impassable currents and contradictory forces, he seized, and by harmonising their directions utilised in practical motors in distant cities the power of Niagara." Is it the reaction against the dry-as-dust drudgery of the law that has produced this dithyrambic effusion, or is the phraseology due to a lack of acquaintance—quite natural under the

circumstances—with the more concise terminology of science? Mr. Tesla, we understand, repudiates the glory thrust upon him, and gives credit for the practical applications of his clever discoveries to the engineers who have supervised the erection of the Niagara and other plants. And he can well afford to do so, for his real achievements in the realm of science are brilliant enough to permit him to dispense with the sensational advertisements of unscientific admirers; but, upon reading the transatlantic rhapsodies in which his name is used with such freedom, we are really inclined to doubt whether Mr. Tesla has not a good opportunity for bringing a successful suit for damages against his worshippers.

Acetylene *v.* Petroleum . . .

THERE has been much controversy of late regarding the future prospects of acetylene and its chances of superseding coal gas in the illumination of our streets, but so far there seems not to be much reason for dismay among the shareholders in our gas companies. More serious cause for apprehension there appears to be among the members of the oil trust, for German experts are inclined to believe that petroleum, which had nothing to fear from gas manufacturers or electric-lighting engineers, may find a successful rival in the illuminating power developed from calcium carbide—or, rather, from acetylene—which can be produced from it without any elaborate plant and by very simple methods. The illuminating power of acetylene is approximately 15 times that of ordinary gas, and since 15 cbm. of the latter give as much light as 6 l. (1·32 gal.) of petroleum, 1 cbm. of acetylene gas suffices to produce the equivalent amount of light. One kilogram of carbide, which furnishes from 300 l. to 330 l. of acetylene gas, therefore is equal in light-producing power to 2 l. of petroleum, and even at this moment, when acetylene production is still in its infancy, is cheaper than this quantity of mineral oil. According to Dr. A. Frank, sen., of Charlottenburg, it would require merely the invention of a portable acetylene lamp to oust petroleum from its dominant position in domestic illumination in Germany, though, of course, the carbide production is as yet too restricted to supply the whole demand covered at present by the use of mineral oils, of which Germany imports annually 1,100 million hectolitres. To supplant this import, 600,000 tons of carbide would be required, to produce which power-plants aggregating 500,000 to 600,000 h.p. would have to be laid down. Nevertheless, the introduction of acetylene as a source of domestic illumination, as far as the supply suffices, would, according to the expert above-mentioned, protect Germany against the effect of all arbitrary and sudden variations in the price of petroleum, and divert a large amount of capital to home industries. Although Germany does not possess such water-power as Switzerland or Norway, for instance, there exist, as Dr. Liebetauz has shown, enormous sources of power in the vast quantities of furnace gases, hitherto wasted, which are developed in the Rhenish-Westphalian districts; and in this regard Great Britain is equally, if not more, favoured. The combination of iron-works with carbide-works has undoubtedly great prospects within the near future, to judge from the many patented processes in which carbide is used, as in the hardening of armour-plate by the Harvey method, for instance, and other technical applications. Among the latter may be mentioned the use of carbide and acetylene for the production of lamp-black, printer's ink, and the manufacture of a black colour for artists equalling in fineness and depth Chinese black. The number of uses for carbide, in fact, is constantly increasing, and with this increase a reduction in price will follow as a corollary, so that acetylene has undoubtedly a chance of becoming the cheapest illuminating material, and thus the tyranny of the oil trust will find its natural limits.

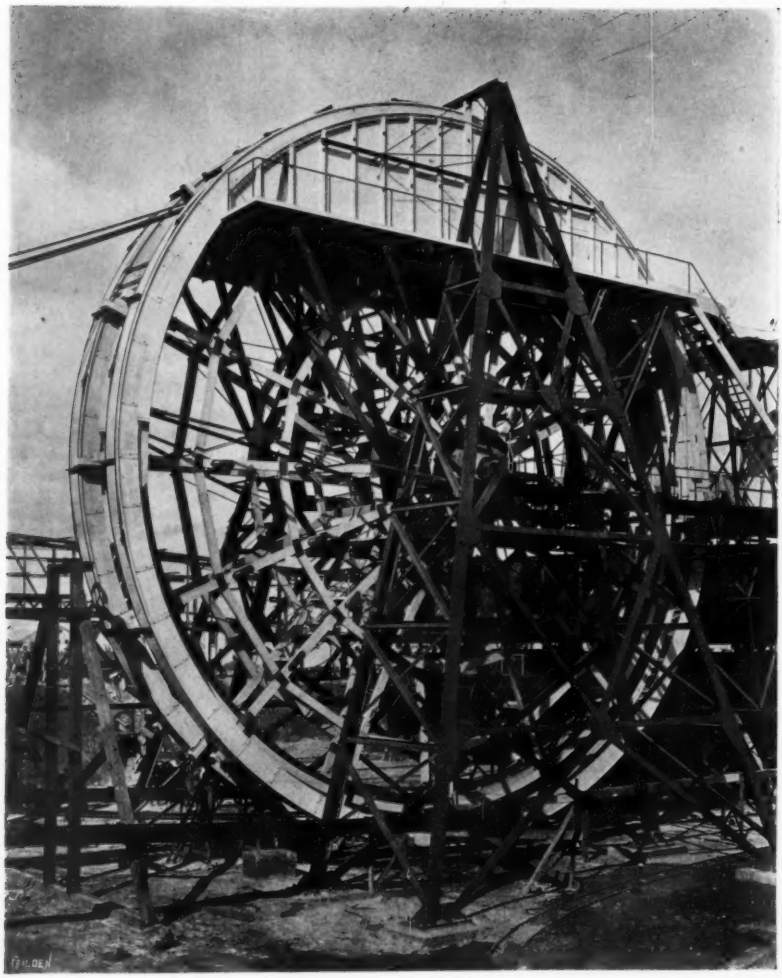
On January 1st will be published the

New Century Number of "Feilden's Magazine."

For full particulars see page 630.

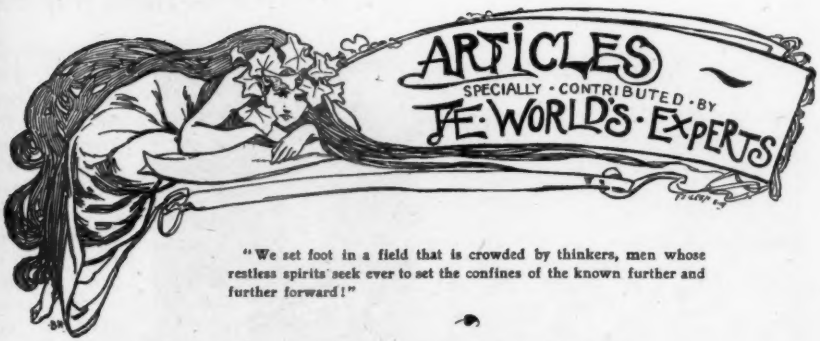
SUP

Supplement to
FEILDEN'S MAGAZINE,
Nov., 1900.



DOUBLE BUCKET TAILINGS WHEEL, 60FT. DIAMETER,
AT THE FERREIRA DEEP MINE.

FOR DESCRIPTION SEE ARTICLE ON "THE MINES OF THE TRANSVAAL."



"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

Some Account of Mining in China.

By ALFRED EDMONDS.

MR. ALFRED EDMONDS is a native of Merthyr Tydfil, Glamorganshire, and is descended from the pioneers of the coal-mining industry in that county. He took a deep interest in the progress of his native town, and occupied many prominent positions there, being, among other things, President of the Chamber of Commerce. Latterly he has identified himself largely with Chinese questions, and at the close of the Chino-Japanese War he went out to China as secretary of an important mining syndicate, and as correspondent to the *Pall Mall Gazette*. Since his return he has written articles to most of the leading magazines on various phases of the Far-Eastern Question, and at the outbreak of the present crisis he was consulted by the Intelligence Division of the War Office, and placed his maps and other valuable information at its disposal.

ANY magazine article dealing with so vast a subject as the mineral wealth of a great country like China, must necessarily be somewhat superficial in character. The area of the country is so enormous, the deposits so varied, and the methods of treatment so diversified, that to do adequate justice to the theme would require several volumes. Anything approaching a history of mining in Far Cathay is therefore impossible here, and the limitations of space compel me to deal, and that with the utmost brevity, with only one or two phases of the subject. Ever since Von Richthofen, the eminent German geologist and traveller, partially unlocked the treasure-house of the magical East, and exposed its latent wealth to the incredulous eyes of Western observers, the attention of mining engineers has been attracted thither. They were, however, forbidden to enter the enchanted areas, and the mining districts were almost as rigidly shut out from the view of European experts as the Forbidden City in Peking was from the curious gaze of the globe-trotter.

Nearly a quarter of a century has elapsed since Von Richthofen wrote his valuable work, and the barriers of exclusiveness which then existed are now less difficult to surmount. The unsuccessful character of the war with Japan gave a great impetus to the march of Western thought in China. The subsequent historic tour of Li Hung Chang through Europe and America quickened general interest in the country. He made many promises, partly

MOUTH OF COAL MINE AT TAI CHI, SHANSI.

from hopes of personal aggrandisement, and partly because of a sincere desire to see the finances of China placed upon a firmer basis. That he was unable to fulfil them was scarcely his fault, because he was opposed on his return by a strong Court faction irreconcilably opposed to anything in the shape of foreign skill or capital. Still, the promises made by him were not without beneficent results. The word had gone forth, and great was the company of syndicates. The winter of 1896-97 witnessed an enormous influx of commercial men into Shanghai. All sorts of panaceas for China's woes were put forward, the more amazing because of their charming disinterestedness. Some of the self-appointed saviours of the country soon got tired of their mission. Others held on like grim Death to the paths they had mapped out for themselves, and, as subsequent events have proved, they went not empty away.

Not the least important of the syndicates to which I refer were those representing mining interests. A number of them have since had valuable concessions granted them. It would be impossible to over-estimate the commercial significance of this change of policy. Up to now it is true that very little development work has been proceeded with on any of the various syndicates' properties. The disturbed condition of the country, consequent on the political unrest at Peking, and the war which may now be said to be terminated, is responsible for this. When, however, the large areas which have been mapped out for foreign exploitation are opened up in real earnest, there will be no finer field in the world for the employment of skilled engineers. There can be no doubt that a great deal of prejudice against the introduction of machinery will be encountered, but it should be remembered that within the memory of living man nowhere was that prejudice more pronounced than in England. It would be misleading to conclude that its existence effectually shuts out foreign energy. Notwithstanding the serious proportions which the Boxer rebellion assumed, encouraged as it was by the more Conservative officials in Peking, the experience of the past four or five years contains many elements of hope. Mr. W. N. Beauclerk, who was then acting as H.M. Chargé d'Affaires at Peking, and I were one day standing on the platform at the newly-built Tientsin Station, watching eager crowds of Chinese hustling each other in their desire to first get on board the train, when he remarked that had anybody told him six years previously that such a sight were possible in China he would have disbelieved him. Equally incredulous, no doubt, would people have been had they been told that in Szechuan, one of the most anti-foreign provinces in the Yangtze Basin, a perfectly-equipped gold milling and concentrating plant would be running

to-day. Frequent contact with foreigners gradually but surely overcomes native bias. In Shanghai, for instance, the rapid growth of the foreign settlements has produced a wonderful change in the minds of the more intelligent Chinese. Though they were staggered at first at the wide gulf between Western civilisation and their own, astonishment at length gave place to appreciation, with the result that they now adopt many Western ways of living. So will it be with mining. When the advantages of modern machinery are seen by them they will not be long in abandoning the primitive processes now in vogue. It may therefore be taken for granted that at no distant date China will be a magnificent market for the products of our engineering works.

Most of the provinces of China contain minerals to a greater or less extent, but the richest would appear to be Yunnan, Szechuan (which may be said to come within the sphere of British influence on the Yangtze), Shansi, Shantung, and the metropolitan province of Pe-chihli. With regard to the two former, all travellers who have been through them unite in regarding them as the richest metalliferous regions in the world. Their minerals have been mined and exported ever since the beginning of the fifth century. The leading emporiums bordering on the Canton River secured their prosperity through their instrumentality. As Newcastle and Cardiff owe their position as ports to-day to the resources of Northumberland and Glamorganshire respectively, so did Canton, Wu-Chow and Yunnan of the olden days owe their pristine greatness as commercial centres to the vast mineral wealth of the south-western provinces of China. The Yunnan mines ceased working for a long time after 1873, owing to the Mahommedan rebellion which raged through the province, but on its suppression, additional facilities were afforded native mining enterprise. While speaking of Yunnan, it would be well to mention the importance of the suggestion made as far back as 1885 by Mr. Archibald Colquhoun. At that time he advocated (as he has done ever since) the building of a railway from our Indian frontier to Yunnan, with the object of tapping the inland trade of Southern China. No industry would be more beneficially affected by such a railway than the mining. By the rapid transport of pumping and mining machinery to the spot the output of the mines would be vastly increased, and a considerable reduction would be made in the price of the carriage of exports as compared with that paid by the road routes. Yunnan is especially noted for "Pocho" and "Talan" (tin mines and gold mines), whilst it also has iron, silver, quicksilver (both native and in the shape of cinnabar), and lead in abundance.

THE COAL REGION, SHANSI.

COAL AT PAO NIU HO, HONAN, IN STACKS OF 10,000 TONS.

Szechuan, the richest of all the provinces, has latterly attracted attention in consequence of its being one of the areas which have come under the jurisdiction of the recently formed Mining Administration, the adviser to which is Mr. W. Pritchard Morgan. It is the duty of this official to suggest to the Chinese Government the advisability of opening up any areas which he considers will yield substantial results, and having discovered them, foreign and native capital will be invited to work them, and no nationality will be excluded. Up to now, very little advantage has been taken of the new mining rules, in consequence of the doubts entertained on the question of security of life and property. In the light of events which have transpired comparatively recently these doubts are not unjustifiable. During my stay in China in 1897 an attempt was made by Chinese to work petroleum wells in the province by foreign methods and with foreign capital. A syndicate was formed with a capital of several hundred thousand taels. The Viceroy of the Province gave two Chinese the necessary credentials to exploit the wells "with the assistance of a foreign expert." When the latter appeared upon the scene a local magistrate set detectives on his track, with the result that they discovered that he and not the native promoters provided the capital. The latter had only given their names, and in return were to be given founders' shares equal to 30 per cent. of the net profits of the Petroleum Company of Szechuan.

The local authorities had, however, received orders prohibiting natives to combine their capital or work with foreigners in any enterprise whatever in the interior of China. They considered that the native promoters had broken the law, and the latter were arrested and sent to the provincial capital for trial. One of them, fearful of consequences, committed suicide, and the other was cashiered. The foreigner made a claim for damages for breach of contract through his Minister at Peking, and after much delay succeeded in getting compensation from the Tsung-li-Yamen.

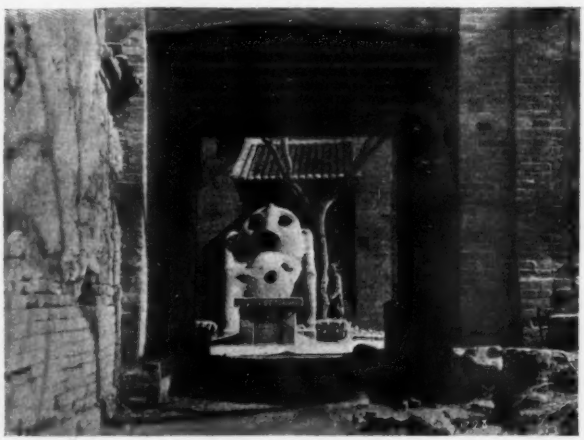
Things have improved somewhat during the last three years, however, inasmuch as there is one mine in the province being operated by foreign machinery, photos of which are reproduced. This mine is situated in the south-western corner of the province, and is known as the "Pao Fu." It is owned by a semi-official company which has a capital of 250,000 taels, or about £40,000. It is under the management of two Cantonese, named Chu-ling-kwan and Tong-sing-kow, both of whom had their mining training in America. They have a splendidly equipped gold-milling and concentrating plant, supplied by Messrs. Fraser and Chalmers, of Chicago and London, and the yield of

the mine operated upon averages half-an-ounce to the ton. That the authorities are now beginning to appreciate the advantages of modern machinery, and are looking with kindlier eyes on foreign methods, may be gathered from the fact that they have raised Chu-ling-kwan (one of the managers) to the position of Taotai or magistrate, and have also made him a member of the Bureau of Foreign Affairs at Chentu, the capital of Szechuan. Through his enlightened interposition it will, no doubt, be much easier for foreigners in the future to prospect this immensely rich mineral region.

Another important consideration in connection with mining in Szechuan is that through the improvements latterly made in the navigation of the Yangtze, due to the enterprising initiative of Mr. Archibald Little, it would be possible to police the higher reaches of the river in case of any serious outbreak against foreigners. If the Chinese are desirous of employing foreign capital in the development of the resources of their country, they should, in spite of the opposition of petty provincial officials, afford some reasonable security for the property of investors. Russia has not hesitated to pour thousands of Cossacks into Manchuria to protect her engineers in the building of her railways. It might be necessary for England to despatch gunboats of a suitable character to the higher waters of the Yangtze. I hope no such necessity will arise, but should it do so, the British Government would be lacking in its duty if it did not follow Russia's example in this respect. No eloquence appeals so forcibly to the Chinese mind as the "gunboat argument."

Despite the fact that the Northern provinces have been the cockpit, so to speak, of the recent war, travellers who know the region unite in the opinion that the inhabitants of this part of the country are less disposed to resent foreign methods than the Chinese of the Southern provinces, and in view of the important concessions recently granted to English syndicates in North China, it is gratifying to know this. Mining experts who have traversed the mineral districts of Shansi, Shantung, and Pe-chihli state that they everywhere met with the greatest courtesy from officials and people, especially in the former province, whose inhabitants are noted for their superior mental qualities. Mr. W. H. Shockley, M.E., one of the highest modern authorities on the mineral deposits of Northern China, was telling me the other day that in the interior of Shansi he was entertained to a European dinner, and that his host's library contained Chinese translations of a large number of Western standard works on engineering.

If Szechuan can be regarded as the richest metalliferous region in the world, Shansi can lay claim to the possession of the largest coal area. Richthofen estimated the anthracite coal field of the province at 13,500 square miles, with a coal content of 630,000,000,000 tons. Of course this estimate is to a large extent a



FIRE GOD, SHIH CHIANG, SHANSI, WHOM THE COLLIERS WORSHIP.

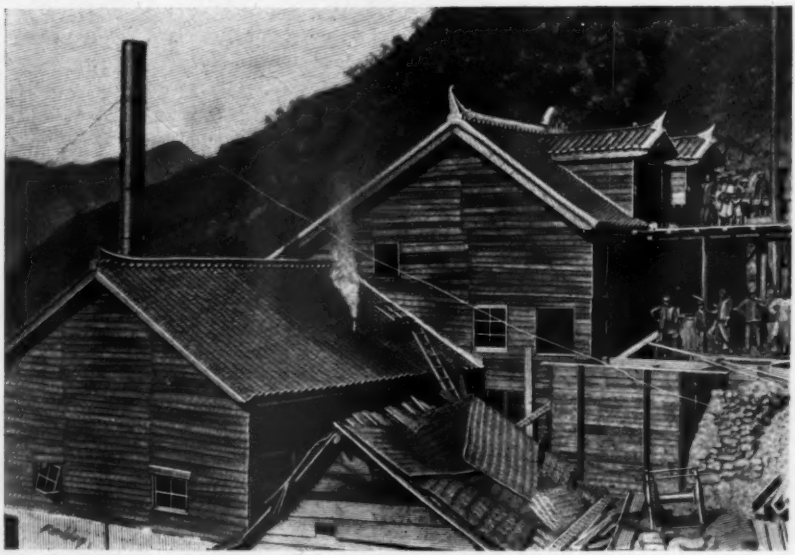
WHERE THE ORE IS DUMPED AT PAO FU.

guess, but there can be no doubt that this one province alone contains sufficient of the "black diamond" to supply the whole world with fuel for many generations to come. The deposit lies like a huge boa constrictor, 200 miles in length, with its head in the south turned in a westerly direction, and its tail in the north curved in a similar way. Its value is, of course, largely increased by the occurrence of immense bodies of iron ores. The methods adopted for coal-getting are extremely primitive, but at the same time ingenious. Mr. Shockley, in a recent report of his, says:—"The plan of mining consists in opening a series of rooms separated by 10 to 20 ft. of solid ground; the size of the rooms depends on the character of the coal, and of the sandstone roof, being larger with the harder coal: the size varies from 15 ft. by 20 ft. up to 35 ft. by 60 ft. There are over a hundred of these rooms in the mine. The dimensions of the room having been decided on, a cut is made completely around it and is carried up to the 'ma shan,' 16 ft. from the floor; at the same time the soft 'mei' is taken out under this by a series of cuts 46 ins. wide by 38 ins. high. When the coal begins to crack—to 'talk,' as the miners say—they stop work in these drifts, and the block soon comes down, parting at the 'ma shan' seam, which is taken down later. We saw one block of coal that had just fallen: this was 50 ft. by 30 ft. by 12 ft. thick, or over 1,000 tons. Wages are paid per block of coal excavated in size 48 ins. wide by 38 ins. high by 30 ins. long for cutting the lower seam of coal, the miners get 200 cash for each of these, and cut about two per day: including lost time, they are said to make seven taels per month, or about a pound. After the 'ma shan' seam has been taken down the roof caves in rather large blocks, some of the rooms being fully 50 ft. high; the roof is sandstone, as it is everywhere in Shansi. The large openings in this mine, with the 22-ft. seam of coal plainly showing by contrast with the lighter sandstone above, was most impressive, and dreams of the wealth and prosperity stored here for future ages flashed across the mind. There was a particularly weird sight in a big room 60 ft.

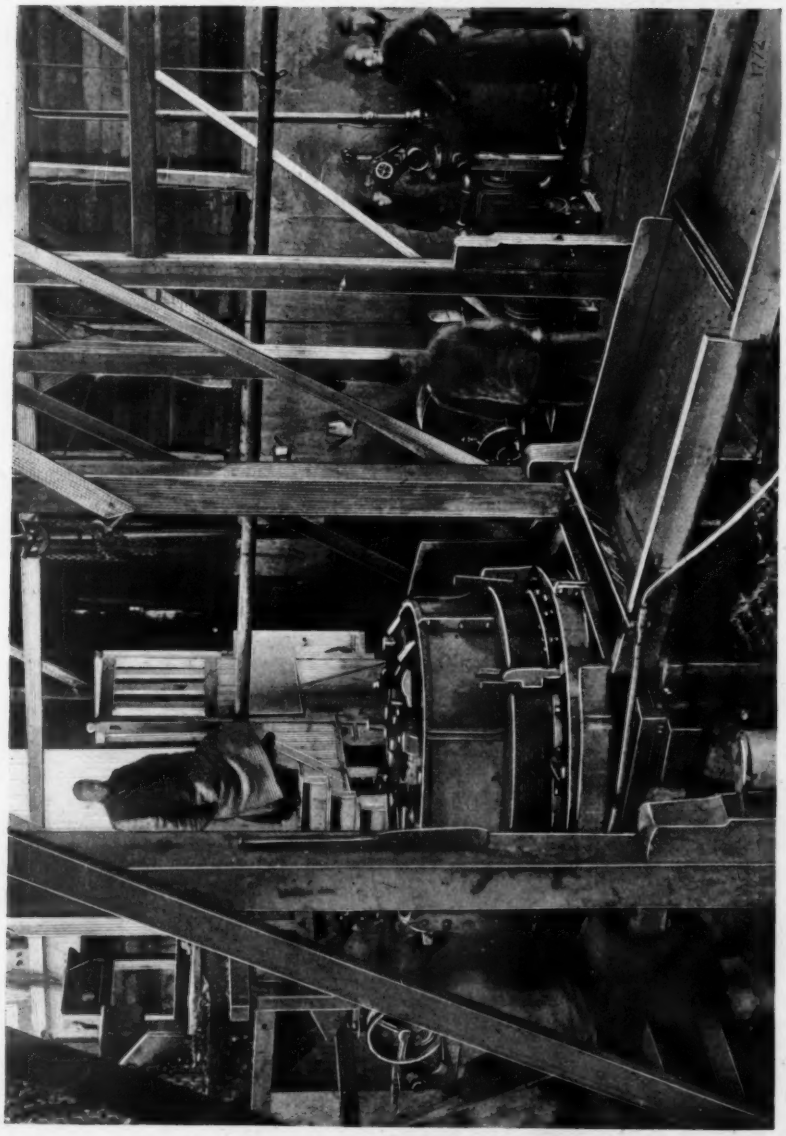
in diameter by 30 ft. high near the shaft, where a monstrous fire was glowing, and on a line stretched between two poles some rags of clothes were drying and men lying all around, some asleep and some smoking opium; another curious thing was a large number of rats which are fed with millet by the miners, and which are said to give warning of accidents."

Throughout the whole of the province there are indications that iron mining has been carried on extensively, all the hill-sides in the iron region being covered with waste dumps. The iron is made in crucibles 19 ins. high and 6½ ins. in diameter. Tubal Cain's process in his antediluvian laboratory could not have been more primitive than that used by the Chinese in the manufacture of iron. The crucibles are filled with various classes of ore, broken very small, coal of the same size, and decomposed coal, or "hei t'u," as the Chinese call it. The proportions are four baskets of ore to one of coal and one of "hei t'u." The crucibles are heated in a stall furnace consisting of two side walls 36 ins. high; the rear wall is formed of a small hut which shelters the men who work the windbox furnishing the blast; the floor of the furnaces here was 50 ins. by 78 ins. This floor is first covered with clay, then comes a layer 7 or 8 ins. thick of coarse coal. On this the pots are placed and the interstices are all filled with small coal, and a few inches of small coal is placed on top. Over all is a cover several inches thick of cinders and ashes, and the front of the furnace is built up of crucibles that have been used. It takes about 16 hours for a heat. The furnace is then allowed to cool for a short time, and the crucibles are taken out with long tongs. When cold they are broken and a cake of iron is found at the bottom if all has gone well. Wrought iron is made from the pig iron manufactured out of the smelting mixture by heating in a small furnace with wood for fuel, and hammering while hot with light hammers.

The iron trade of Shansi has declined considerably during the last quarter of a century, the manufacture of the Hanyang



EXTERIOR OF CRUSHING MILL, PAO FU



INTERIOR OF CRUSHING MILL PAO FU.

ironworks at Hankow, having ruined the market for the Shansi product. When, however, the machinery which will shortly be imported into the province for the conversion of the collieries into modern concerns will have demonstrated what it is able to do, the Shansi ironmakers may follow the example of Hankow, and, by the introduction of the latest methods, revive what was once a thriving industry.

Gold-mining has been carried on more systematically in Pe-chihli, the metropolitan province, than in any other part of China. The output of the mines which are working with the consent and under the official cognisance of the Chinese Government, amounted to nearly 50,000 ounces in 1898. Gold-washing has been practised in the streams for centuries, and upon it China has depended for her principal gold supplies in the past. When Li Hung Chang was superintendent of the trade of Northern China, a position which enabled him to exercise almost autocratic power in all industrial matters, he introduced European machinery into several districts, but whether from want of proper supervision or native prejudice against the "instruments of the devil," the mines never succeeded under the new régime, and in one or two instances the native managers went back to the old systems of working. One veteran mine-owner, Chu Yu Chee, who was largely identified with the innovation of Li Hung Chang, is a firm convert to Western methods, and as his opinion on mining is highly valued throughout China, his influence may do much to break down the prejudices of an ignorant conservatism. There is gold all over the province, but the principal field is that of Ye-hol, some 200 miles north-east of Peking. Here the precious metal is found in quartz veins in limestone. The ore bodies are, however, very erratic in character, some of the lodes being very poor and some very rich. On the whole they yield an average of one ounce to the ton. Native mine-owners are supposed to pay a royalty of 10-24ths of the profits to the Government, but they so manage to cook

EXTERIOR OF GOLD REDUCTION MILL, PAO FU.

the accounts that the Board of Revenue gets precious little from this source of income.

While on the subject of mining in Pe-chihli I may be pardoned for narrating a story told me by Wong Kai Kah, a brilliant young Chinaman, who was first secretary of the Chinese Imperial Railway Administration. It refers to a mining expedition which was attended with a considerable degree of good fortune. An impecunious Emperor, whose love of luxury had led to a depletion of the national coffers, called his Grand Council together one day, and told them they must get him some gold. He had heard that the precious metal was to be had in abundance if it was dug for, and he bade them proceed to the richest province and conduct the necessary mining operations. The mandarins of high degree knew as much about mining as a porcupine does of dancing a saraband, and they were sorely perplexed. The alternatives meant the losing of their heads or their yellow jackets. Of the two they probably preferred the former indignity, for the latter involved the deprivation of their most privileged degree, and the losing of "face." And, although it may sound paradoxical, the aristocratic Chinaman prefers losing his head to losing "face." One of the younger members of the Council, a Machiavelian Mongol, came to the rescue by proffering to find the gold required. They gladly left the matter in his hands, and he proceeded with plenary powers to the province in question. On arriving at his destination he sought out the wealthiest residence he could find, and presenting himself to the occupier, told him that he was armed with an edict from the Emperor to dig for gold under that house. The owner expostulated, but it was of no avail. The Court emissary was obdurate. The house must come down, and the bones of the owner's ancestors must be disturbed, for allowing which the said owner would suffer certain purgatorial tortures. There was one way out of it, said the Grand Councillor. If the owner would give him thirty thousand taels he should be left in undisturbed possession. The amount was

PAGODA IN THE COLLIERY DISTRICT NEAR PU CHOU FU, S.W. SHANSI.
THE TREES ARE PERSIMMONS.

quickly forthcoming, and the experiment being accompanied by such excellent results, was adopted in regard to all the other large residences in the province. The gold was got together, the wrath of the Son of Heaven was thus appeased, and so concluded one of the most successful mining enterprises ever conducted.

To return to the sober phase of the subject, two things are necessary in order to make China the most successful mining country in the world. One is the improvement of communications by the opening up of the inland waterways, and the carrying out of a vigorous railway policy; the other a determination on the part of foreign Governments to see that all contracts entered into with their subjects are rigidly carried out by the Chinese. With regard to the former, a beginning had been made prior to the recent disastrous outbreak. The capital had been connected with the coast at two points—Tientsin and Shanhaikuan. The main trunk line, from Pekin to Hankow on the Yangtze, had been commenced. But of course a large amount of damage has been done which will take some time to repair. Plans have been completed for the construction of branch lines, which will tap the Shansi coalfields. A more important line still is the projected railway from Tientsin, in the North, to Chinkiang, near the mouth of the Yangtze, with an extension to Canton, on the West River. The richest mining provinces (Szechuan and Yunnan) are, however, quite neglected in matters of railway communication, and the British Government has actually stopped the construction of the line from Mandalay to Kunlong Ferry, on the borders of Yunnan. This policy is in strange contrast to the attitude adopted by Lord Salisbury in the early eighties. When approached on the question of a railway, having for its objective the tapping of the trade of Yunnan and Szechuan, he said: "You provide a powerful and solvent company, we will assist you as far as we can to bring it to the edge of British territory; and when we have done so, I have not the slightest doubt that we shall be able to penetrate into foreign territory whenever we think it desirable to do so." Until this line, or the alternative one from Moulmein, through Northern Siam, and thence to Sumao and Yunnan, is constructed, the mining industry of the two provinces referred to will never witness any great expansion.

The great stumbling-block which has hitherto been in the way of foreign mining enterprise in China has been the difficulty experienced in obtaining anything like a valid title to properties offered for exploitation. Even where private owners were willing to negotiate for the sale of land, the local official would step in and forbid it on the ground that no foreigner was permitted by the law to own landed property in China. Events before the war indicated that this *pons asinorum* had at length been surmounted. The Tsung-li-Yamen itself had acknowledged contracts entered into with natives in the interior, and these have been ratified by Imperial Decrees. Whether there will be any attempt to wriggle out of these agreements remains to be seen.

Much depends upon the manner in which the Allied Powers comport themselves at the present juncture. Any vacillation will put back the hands of the clock for years, and will undo all the progressive work which has been accomplished. If any leniency is exhibited towards the instigators of the recent attack on the Legations, it will at once be construed into evidence of weakness, and the anti-foreign officials in Peking will pursue their old devices with redoubled energy. Any serious departure from the lines of the policy laid down by the German Emperor will be fatal to enterprise in China. Prince Tuan, Kang Yi, Tung Fuh Siang, and Yung Lu, as the aiders and abettors of one of the most flagrant breaches of international law ever committed, must be executed as a preliminary to negotiations for peace, and the woman who has become ruler of the country by the committal of a series of crimes of the foulest character must be deposed. No beneficent results will accrue from the success of the Allied Forces unless some such policy is vigorously carried out—a policy which will prove once and for all

that if foreigners are wantonly attacked, vengeance speedy and terrible will be exacted.

I will not close these observations in a pessimistic vein. Large sections of Chinese are undoubtedly infected by the contagion of progress. With the rapid development of China's mineral resources the purchasing power of her people will be vastly increased. Their wants are now restricted by their earnings. Given better wages, increase their productive capacity, and their wants will necessarily be multiplied. China therefore bids fair to provide future generations with one of the finest markets in the world, and thus justify the prophecies of all those who have made the country the subject of thoughtful study.

. The author is indebted to Mr. W. W. H. Shockley, M.E., for a number of the photos which appear in this article, and to Mr. G. W. Hall, M.E., J.P., Western Australia, for its revision.

Alfred Edmonds

LI HUNG CHANG AND THE AUTHOR AT THE VICEROY'S RESIDENCE IN PEKIN.

The Greatest Gold Mine in the World.

By H. F. BULMAN, A.M.Inst.C.E., F.G.S., M.Fed.Inst.M.E.

Of the gold mines of the world, Mount Morgan is the most remarkable, whether we regard it from an industrial or from a scientific point of view. In its splendid isolation—a gold-bearing hill in the midst of barren hill, sin the vastness of its wealth, in the mode of occurrence, and in the extraordinary purity of its gold, in the economical getting and treatment of the ore, it stands unique and unparalleled amongst gold mines.

It is situated some 26 miles south-westward of Rockhampton, the principal port of Central Queensland. A railway now connects them. At the time of the writer's visit, in July, 1898, the railway was not completed, and the last five or six miles of the journey, across a steep mountain ridge known as the Razorback, had to be accomplished by coach. Hill and dale, clothed with grass and fairly well wooded, give the country a pleasant aspect.

Mount Morgan rises 520 feet above the level of the River Dee, which flows near its base, and 1,225 feet above sea level, and covers an area at its base of 200 acres or more. The Company hold 640 acres freehold and 72 leasehold. In its contour the hill approximates to the "crag and tail" formation, being steep on one side with a long slope on the other.

Surrounding it are many hills similar in appearance, but though, needless to say, the whole district has been carefully and repeatedly prospected for gold, no similar auriferous deposit has been discovered. Yet the district is distinctly auriferous. Alluvial diggings were numerous in the neighbourhood long before the discovery of Mount Morgan. Gold was got in the streams running around its foot, but the black ironstone boulders scattered over its surface led the early miners to conclude that no gold would be found in it. It was known as the Ironstone Mountain, and for long the mining prospector passed it by.

ITS DISCOVERY.

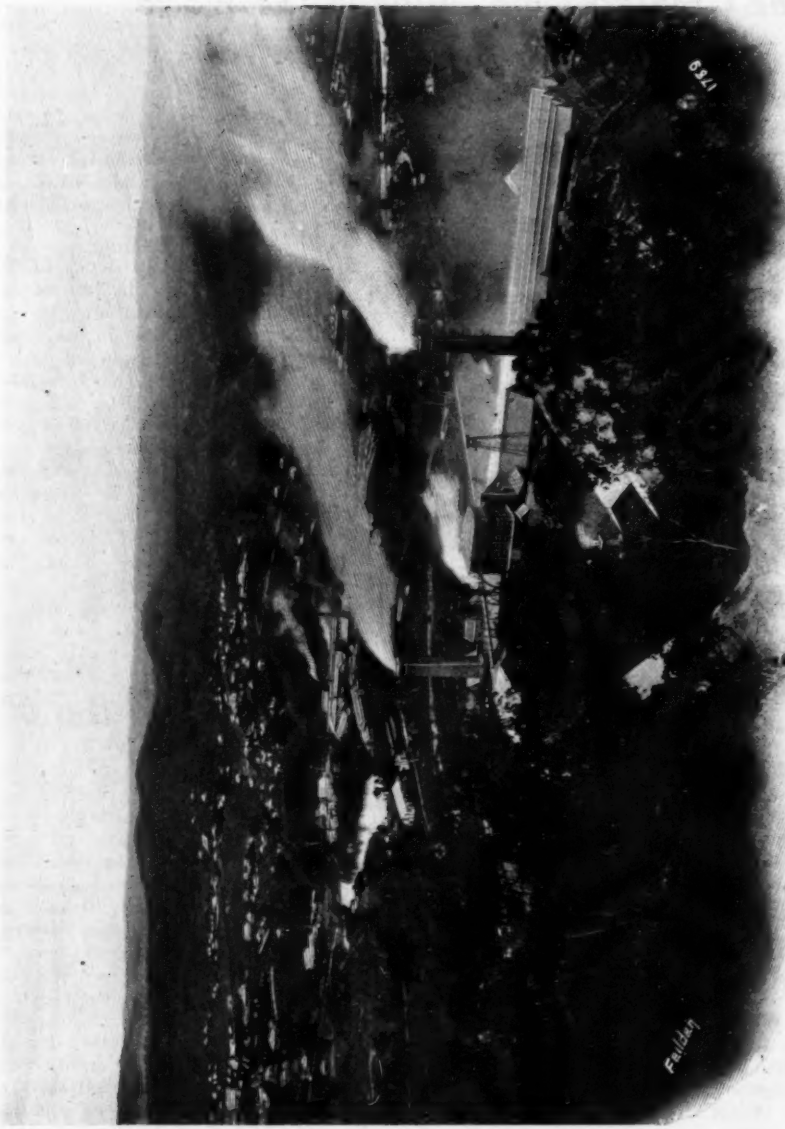
It was not till 1882 that its hidden wealth was discovered. In July of that year two brothers, Edwin and Thomas Morgan, were prospecting in the neighbourhood, and the attention of one of them was directed to the black boulders lying about the surface. He took away samples, which proved to be full of gold, the assay value going as high as 3,700 ozs. to the ton. Another brother, Mr. Fred Morgan, at one time Mayor of Rockhampton, joined them. They took up as much of the ground as they could, and for some months the three brothers camped out there exploring. They were then joined by a few other residents of Rockhampton; mining operations were commenced, and a stamp battery ordered.

Subsequently, in 1886, they formed themselves into the Mount Morgan Gold Mining Company, Ltd., with a nominal capital of £1,000,000 in £1 shares.

FINANCIAL RESULTS.

From July, 1886, to May 31st, 1899, a period of 13 years, 1,968,920 ozs. 8 dwt. 13 grs. of gold have been obtained from 1,054,687 tons of ore treated, an average yield per ton of 1 oz. 17 dwt. 8 grs. £5,050,000 have been paid in dividends on a paid-up capital of £875,000, the return per share (17*s.* 6*d.* paid-up) being £5 1*s.* £2,802,439 have been spent on the works during the same period. This is probably the financial record for gold mines.

During their last year ended May 31st, 1899, 166,078 ozs. 18 dwt. of gold have been obtained from 204,502 tons of ore treated. The gold realised £664,143. The expenditure was £370,496, and



GENERAL VIEW OF MOUNT MORGAN MINE FROM UPPER PART OF THE HILL.

£350,000 has been paid in dividends, equal to 7*s.* per share.*

GEOLOGICAL FORMATION.

Geologically the country consists of sedimentary strata, grits, and shales, which have been altered into quartzites and crystalline compact rocks by igneous action.

From fossils found in the neighbourhood some authorities have assigned these rocks to the Permo-carboniferous period.

About a mile to the west of the mountain is a deposit of coarse, gritty sandstone, more than 100 ft. in thickness, which Mr. Robt. L. Jack, late Government Geologist of Queensland, has recognised to be the same formation as extends widely over Central and Northern Queensland, known as the "Desert Sandstone," and considered to be of Cretaceous age. Numerous dykes of hornblende, granite and porphyritic dolerite intersect the metamorphosed sedimentary strata. Iron pyrites in large quantities, carrying more or less gold, is scattered throughout. Pyritous quartz reefs bearing gold in comparatively small quantities occur in the immediate neighbourhood of the Mount. The upper portion of the Mount, where the working commenced, and which proved to be so very rich, is a confused agglomeration of ironstone, silicious sinter and aluminous deposits. In the geological museum at Brisbane the writer noted the following amongst the specimens from Mount Morgan, all of them carrying gold:—Earthy red hæmatite, aluminite, iron-stained quartz, pyritous silica, iron pyrites, copperas, silicious sinter, sintery quartz, limonite, some of it coated with iridescent oxide of iron, ochre, etc.

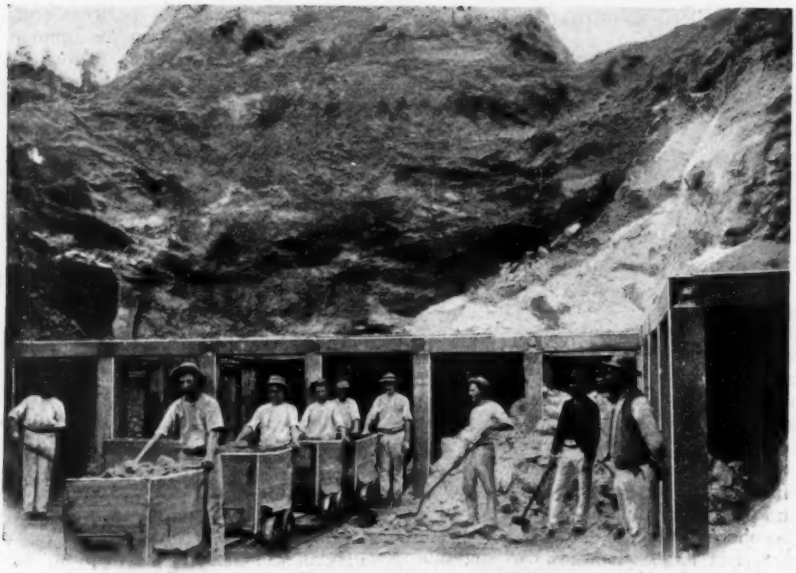
This variety of specimens may convey some idea of the extraordinary mixture. Throughout this confused mass the gold is irregularly disseminated in particles of microscopical fineness, most of it invisible to the naked eye, what is visible being of the fineness of flour. It is undoubtedly a secondary formation, having been dissolved or decomposed from its original matrix and reprecipitated. Its purity is remarkable, being unequalled, in the opinion of Dr. Leibius, Assayer to the Sydney Mint, by that of any other gold hitherto found. Gold as found in its native state is almost always alloyed with silver and copper, and other impurities. Assays of the Mount Morgan product by Dr. Leibius showed 99·7 per cent. of gold, the rest copper with a trace of iron. The value of this is £4 4*s.* 8*d.* per oz. To compare with this it may be mentioned that the value of West Australian gold runs about £3 16*s.* per oz. The gold now being mined at Mount Morgan at greater depths is not characterised by this extraordinary purity.

The auriferous deposit is bounded on its western side by a big vertical dyke of Kaolin, or China-clay, in which no gold has been found. The removal of the upper 200 ft. of the mountain by quarrying has left this dyke standing like a bare wall. All levels are measured from the original top of the mountain. To give an idea of the size of the deposit, at the 195 ft. level the payable ore extends about 700 ft. from west to east and 500 ft. from north to south, and 260 ft. lower down, at the Linda Tunnel level, the width of the gold-bearing ground remains about the same, viz. 700 ft. Sulphide, or Mundic ore, is first met with at a depth of 320 ft. from the top of the hill at the level of the Grass Tree tunnel. Above this the rocks have been oxydised by atmospheric influences. The high grade ore, running 5 to 6 ozs. per ton, is confined to the upper part.

Mount Morgan is now a low-grade mine, but owing to the immense supplies of low-grade ore, and to the remarkable economy of treatment which has been achieved, its future as a highly profitable undertaking is assured for many years.

As to the origin of the gold, there can be little doubt that it has come from the pyritous beds below, but how it has been concentrated in such large quantities in this one isolated spot is not easy to understand. The identity of the silicious sinter, which forms so large a part of the upper portion of the Mount, with the geyser deposits of New Zealand and other countries, led Mr. Jack to think that they might have

* Since this paper was written the figures for the year ended May 31st, 1900, have been published. They show a return of 187,852 ozs. of gold from 239,276 tons of ore mined and treated—a considerable advance on the previous year.



SQUARE-SET TIMBERING UNCOVERED BY THE DEEPENING OF THE OPEN CUT.

had a similar origin. The extending explorations of the mine, however, have rendered this geyser theory untenable. Recent developments prove that the dolerite dykes which intersect the stratified rocks also cut the auriferous sinter and ironstone deposit overlying them, though the dolerite is entirely altered in character. This proves the deposit to be much older in date than Mr. Jack previously supposed, and had it been produced by a geyser it must almost certainly have been denuded.

The gold, however, may have been brought up in solution by a thermal spring, and have been deposited in the cracks and fissures formed by the previous intrusion of igneous dykes. There are evidences against the presence of a temperature higher than that supplied by a thermal spring.

Mr. C. S. Wilkinson, at one time Government Geologist of New South Wales, has stated some of these to be the hydrated condition of all the ores which undergo a radical change in the roasting process; the existence of large quantities of iron oxide intimately mixed with the silica, and the absence of any silicate of iron; the presence of considerable percentages of bisulphide of iron, $Fe S_2$, which is changed at about 400° F. to Fe S, parting with one atom of sulphur.

THE GETTING OF THE ORE.

The upper part of the mountain has been removed by quarrying in a succession of stages or benches, each about 30 feet in height. Nowhere else in the world is rich auriferous stone thus got in great quarries extending hundreds of feet in length and breadth. This surface excavation has now reached a depth of 255 feet from the original summit. Whilst it has been proceeding, the strata below have been explored and opened up by sinking shafts and driving tunnels.

The workings centre round one vertical shaft, called the Crown shaft, which has reached a depth of 650 feet. Levels are driven at vertical intervals of about 40 feet,

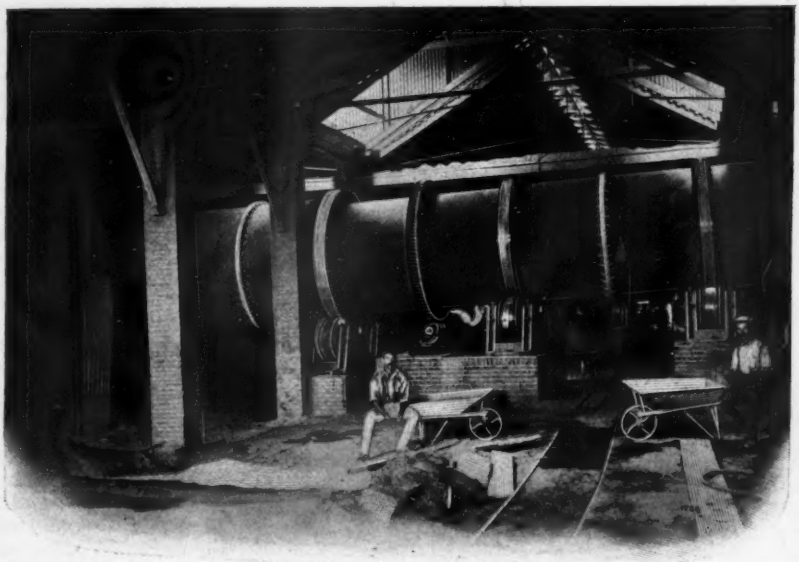
allowing for five or six floors of overhand stoping between each level. The whole of the underground workings are timbered with "square set" timbering, the sets being 7 ft. 9 ins. in height, centre and centre, by 6 ft. long by 5 ft. wide, and floored with planks. These are kept close up to the faces of the stopes, and render the workings safe and pleasant, more like a clean and roomy cellar than the ordinary workings of a mine. The cost of this timbering runs about 4s. a-ton for labour and materials. As the floors

The sulphide or mundic ore yielded on an average 2 ozs. 8·03 dwts. of gold per ton. The bulk of the oxidised ore was low grade, yielding 8·07 dwts. per ton, but 40,803 tons of the oxidised ore gave 19·21 dwts. a ton.

Most of the development work was being done at the 512-ft. level, where good ore exists.

LABOUR AND WAGES.

The number of persons employed in 1898 was 1,446—



REVOLVING FURNACE IN USE AT THE MOUNT MORGAN MINE.

are abandoned, the spaces inside the timbering are filled with waste stone. The deepening of the Open Cut above uncovers the old stope timbers. Last year 1,100 sets were thus recovered, and most of it used again in the lower levels.

Much the larger proportion of the ore is still being got from the Open Cut—158,283 tons last year, as compared with 43,365 tons got by underground mining. 30,069 tons were sulphide ore, and the rest oxidised.

420 on treatment of ore,
300 „ mining and quarrying,
400 labourers, etc.,
266 in mechanics' shops,
60 „ construction works.

Work continues constantly in three eight-hour shifts daily. A usual datal wage is 8s. a shift. Men working underground with machine rock drills get 10s. a shift.

When seeing the mine the writer went

into the face of a stone drift at the 450-ft. level, which was being driven 7 ft. high by 6 ft. wide in very hard stone, at a contract price of £3 2s. a foot, the Company supplying two Ingersoll machine-drills and the compressed air to drive them, and the workmen paying for their explosives and candles. Twelve men were engaged, four in each shift. There is very little piece-work. During last year £150,998 were spent on wages, and only £3,011 on work done on contract.

There is an efficient system of organisation and discipline.

Directly responsible to the managing director, Mr. Vincent Dowling, are the following chief officials:—The metallurgical engineer and superintendent of treatment, the mechanical engineer, the mining manager, the mining captain, the accountant, the architect and builder, the foreman of brickyard, the surveyor. The duties of these officers and the relations between the different departments are laid down in a printed statement of rules and regulations.

METALLURGICAL TREATMENT.

In the metallurgical treatment of gold ores Mount Morgan has gone through a long and costly, but instructive, experience, leading to a highly satisfactory result. Almost every process has been tried, and a system of chlorination treatment has been evolved which, in efficiency of extraction and economy of cost, stands unrivalled. Indeed, it is a new revelation of what can be achieved by the chlorination process.

From an extraction of 40 per cent. at a cost of over £2 a ton, progress has been made to an extraction of 95 per cent. at a cost of 10s. a ton.

The first process adopted at the start in 1882 was the ordinary wet crushing in stamp batteries and amalgamation with mercury on copper plates. The unusual richness of the ore for some time concealed the fact that more than half the gold contents were being lost in the tailings; 2 ozs. per ton were being got, but before long assays of the tailings revealed that they were carrying away 3 to 5 ozs. All kinds of crushing and amalgamating machines were tried — Berdan pans, Wheeler pans, Chilian mills, Huntington mills, and many others—but all in vain.

Even when crushed to an impalpable powder in an agate mortar in a laboratory experiment and amalgamated with mercury, much of the gold remained attached to the minute specks of sand.

Though the gold is "free," and not in chemical combination, yet its microscopical fineness, and also, as suggested by Dr. Leibius, the probability that many of the tiny particles are coated with other substances, such as oxide of iron, prevent its efficient extraction by crushing and mercury amalgamation. It was recognised that the way of success lay in some chemical process of treatment. In 1884, on the advice of experts from the Gympie Gold Field in Queensland, the "Plattner" process was tried for treating the tailings. Professor C. F. Plattner, Assay Master at the Royal Freiberg Smelting Works, in 1848 suggested a system of roasting gold ores and then dissolving out the gold by exposing it to chlorine gas. It was not a success with the Mount Morgan stone, yielding only a small percentage of extraction, and was therefore abandoned.

In 1885 laboratory experiments made at the mine showed that all the gold could be extracted by roasting the ore, and treating it with chloride of lime and sulphuric acid. A plant designed by Messrs. Newbery & Vautin, of Melbourne, involving barrel chlorination was erected the same year.

There were ten revolving barrels, made of wrought-iron, lined with sheet lead and wood. A successful extraction of the gold was achieved, but the mechanical difficulties with the barrels were so great, and the cost of maintaining and repairing them was so high, that in 1887 this plant was superseded by improved appliances on similar lines.

In each of the three main divisions of the process—crushing, roasting, and chlorination—many machines and many appliances have been tested. Step by step and year by year improvements have been made, till now a high degree of efficiency has been attained. In 1891 the "Macarthur Forrest" cyanide process was tried, but did not prove satisfactory.

The problem was not simply to extract all the gold, but to do this at such a cost as would leave a profit on low-grade ore.

THE WEST WORKS.

At the present time in the West Works, which were opened in September, 1896, low-grade ore is being treated so as to yield 95 to 98 per cent. of its contained gold at a cost of about 10*s.* a ton for crushing, drying, roasting, and chlorinating. Thus ore containing only 3 dwts. of gold per ton can be treated profitably.

THE QUARRY, MOUNT MORGAN.

The works were designed to treat daily 500 tons of low-grade oxidised ore. Last year 130,776 tons were dealt with. They are arranged so as to utilise the force of gravitation as far as possible. On the top level are four storage bins, each having a capacity of 250 tons of ore. From the bins the ore is delivered into Gates' crushers, of which there is one to each bin, and thence falls into revolving driers. These are steel cylinders lined with firebricks, set on a slope, so that the ore slides through them, with a fire at the lower end, and at the upper an outlet for the products of combustion. The dried ore is raised by elevators into hoppers placed above 16 Krupp ball mills. In these the ore is crushed fine enough to pass through wire sieves containing 400 holes to the square inch, which form the outlet from the mills. Thence it falls into revolving cylindrical furnaces. There are four of them, and they are of similar construction to the driers, but larger, and the temperature in them is higher. The passage of the ore through these furnaces occupies about a quarter of an hour. To each furnace are assigned two coolers, one on each side. These are revolving circular cylinders which, as they revolve, dip into a stream of water running beneath them. After going through the coolers the ore is mechanically conveyed to

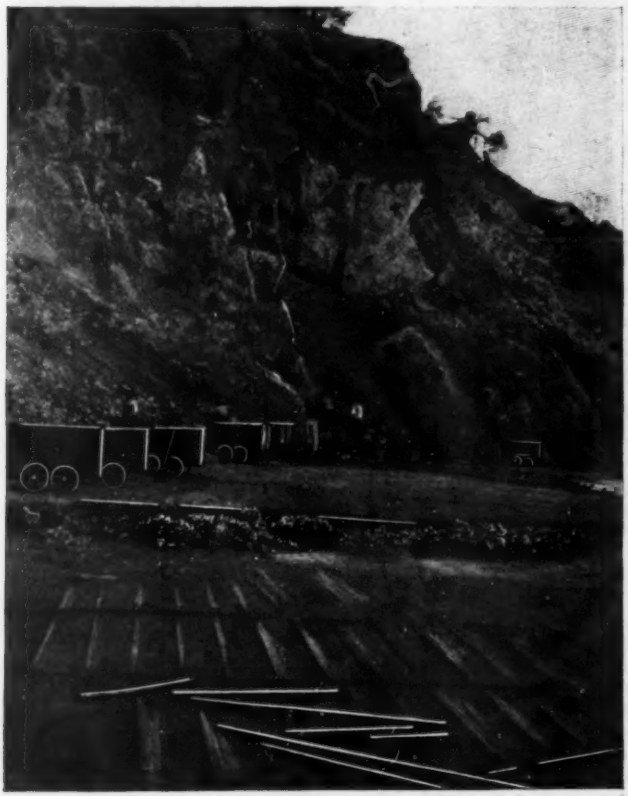
another set of hoppers, from which it is discharged into the chlorination vats.

There are sixteen of these vats, each having a capacity of 100 tons. Chlorine gas is generated from the chemical decomposition of salt, manganese, and sulphuric acid, in stills round which a current of steam is circulated. The chemical reaction is expressed by the following formula :—

$$Mn\,O_2 + 2Na\,Cl + 3H_2\,SO_4 = Mn\,SO_4 + 2Na\,HSO_4 + 2H_2O + Cl_2$$

—the resulting products being manganous sulphate, sodium sulphate, water, and chlorine. The manganese is obtained from the neighbourhood of Gladstone, a little place on the coast of Queensland, not far from Mount Morgan. The salt comes from South Australia, and the sulphuric acid is made at the mine from sulphur (brought from Japan) and nitre, a special plant having been erected for the purpose. Mr. H. A. B. Leipner, the works chemist, states in his report for the year ended May 31st, 1899, that 922 tons of manganese were used, 873 tons of salt, and 2,925 tons of sulphuric acid, the total cost of these materials being slightly over £17,000.

The chlorine gas passes into scrubbing towers, where it is absorbed by water. These towers are filled with broken glass or crucibles or flint stones, amidst which the gas makes its upward way, and is brought into intimate contact with the water trickling downwards. The chlorine water flows into storage tanks, from which it is run into the vats on the top of the ore.



MOUNT MORGAN: BENCH WORKING.

In percolating through the ore it dissolves out the gold as chloride of gold. This percolation occupies about 24 hours. The chloride of gold solution is drawn from the vats by vacuum pumps, and is delivered into storage tanks, whence it flows into charcoal filters. These consist of shallow tanks filled with vegetable charcoal in small pieces.

Charcoal has the property of precipitating gold from chloride of gold solution, as was first demonstrated by Dr. Percy, F.R.S., in 1869. Every month the charcoal with its precipitated gold is removed from the filters and burnt in small furnaces. The ashes are smelted with borax, and the gold run out into ingots.

MACHINERY AT THE WEST WORKS.

The engines connected with these works comprise the following :—

Driving the four Gates' crushers, the 16 Krupp ball mills, the four elevators, and four revolving driers, is a triple expansion engine of 400 nominal horse-power, made by Fleming & Ferguson, Ltd., of Paisley. The cylinders are 15 ins., 24 ins., 39 ins. by 24 ins. stroke, the steam pressure in each respectively being 149 lbs., 28 lbs., and 4 lbs. A vacuum of 21 lbs. is obtained by a surface condenser placed outside the engine house, consisting of pipes with cold water flowing over them. The driving-wheel is 12 ft. in diameter, by 2 ft. wide on the face.

Each of the revolving furnaces is driven by a separate little engine of 6 nominal horse-power, and two more similar engines drive the revolving coolers.

A Bumsted & Chandler compound vertical engine of about 20-horse power drives the vacuum pumps connected with the leaching vats and the force pumps to the storage tanks.

WOOD v. COAL AS FUEL.

To supply steam to all these engines there are four Babcock & Wilcox water-tube boilers raising steam at 150 lbs. pressure. Wood was the only fuel in use for boilers and furnaces in July, 1898. The contract price delivered at the mine was 15*s.* a ton. It was estimated that a ton of it was equivalent to half a ton of best Welsh steam coal. Wood has the advantage of being cleaner and of occupying much less labour and attention in stoking. The fires require replenishing with wood only at long intervals of about 1½ hours, and these boilers could be run for two months before they needed cleaning.

Now, since the completion of the railway from Rockhampton, coal is used in firing all the steam boilers, as considerable economy is thus effected. During the half year ended May 31st, 1899, when coal was first introduced, £13,149 was spent on wood and charcoal (the two being combined in the statements of accounts) and £4,930 on coal, total £18,079. During the next half-year, ended Nov. 30, 1899, wood and charcoal cost £9,840 and coal £7,580, a total of £17,420, though the output of ore rose to 118,658 tons, being 16,407 tons more than the average of the two previous half-years.

The ore treated at the West Works, which at present amounts to more than half the entire output of the mine, is got by quarrying from the Open Cut above. It falls into trucks, and is hauled by a loco. along a tunnel to the works, at the low cost of about 2*s.* a ton. Fifteen shillings a ton, or less than 4 dwts. of gold, covers the total cost of getting and treating the ore.

About a year ago a new works was started for the treatment of mundic or sulphide ore.

SHAFT FURNACES.

The special feature of these works is a new type of furnace, called a shaft furnace, which has been designed by Mr. G. A. Richard, the metallurgical engineer. The circular revolving furnace has proved itself to be most suitable for the roasting of oxidised ore, but not for the mundic ore. The latter needs a longer and more intimate exposure to the heat.

At the Upper Works reverberatory furnaces have been used for some time. They are expensive in labour, as the ore has to be stirred about continually by attendants with long rakes.

As an improvement on these the Ropp furnace was adopted. This furnace was patented by Mr. Alfred Ropp in the United States of America on January 1st, 1895. In it the stirring is done mechanically by a number of metal blades fixed at intervals of a few inches to a crossbar. These extend across the whole width of the horizontal hearth, which, in the Mount Morgan furnaces, is about 8 ft. by 105 ft. in length. The crossbar is fixed to a carriage moving on wheels below the

MOUNT MORGAN: SQUARE SETT TIMBERING UNCOVERED BY OPEN CUT.

hearth and attached to an endless rope. The metal blades, moving slowly forward over the surface of the hearth, stir up and carry forward the powdered ore whilst it is exposed to the flames of the fires. This occupies a period of about five hours.

In the shaft furnace the force of gravity is utilised in place of mechanical propulsion. The furnace is set up on its end, so to speak, and the ore falls through it. In its original inception it consisted of a rectangular brick chimney, in which were built tiers of brick arches with apertures in the middle and towards the sides alternately, through which the ore fell during its downward passage.

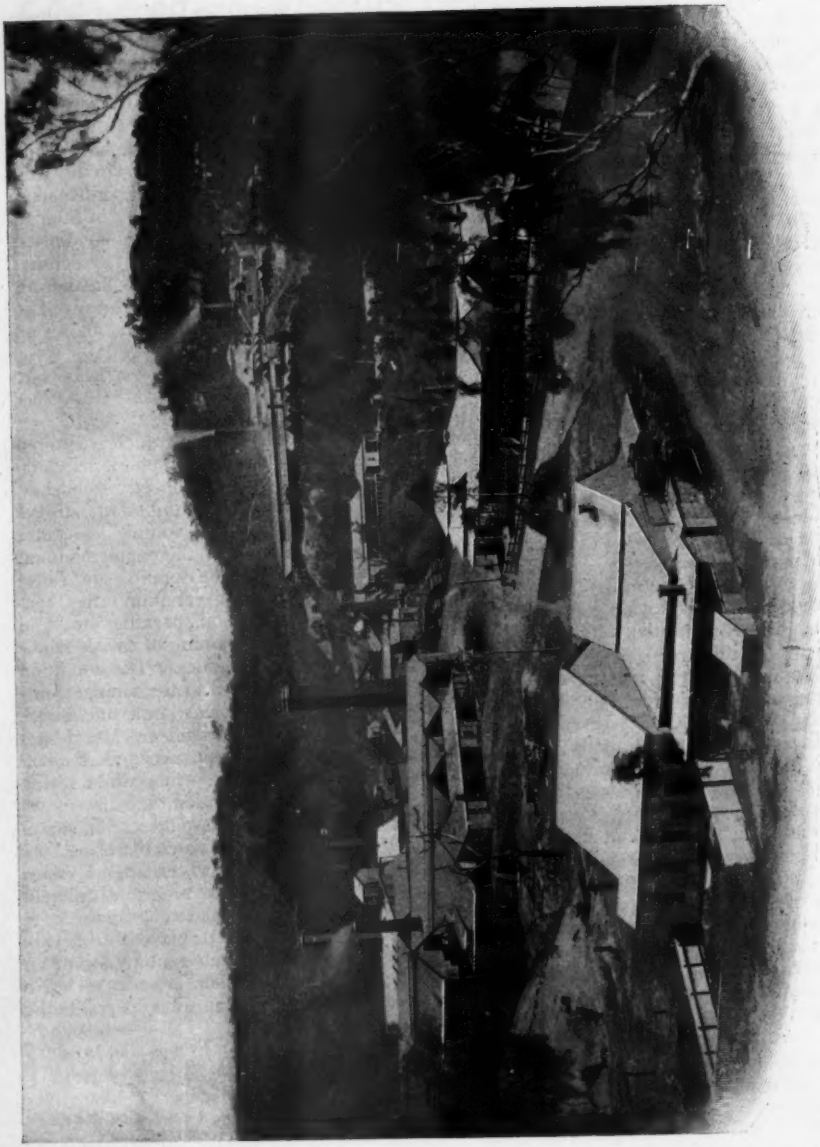
It was found that with this arrangement the ore came through too fast to allow of its efficient calcination. Brick shelves were built, therefore, horizontally just below each side aperture to catch the ore as it fell, and compressed air jets were inserted beside each shelf, so that by turning a tap the powdered ore could be blown off the shelf at such intervals of time as were thought best. Great economy was effected by these furnaces in comparison with the reverberatory and the Ropp. Whilst the Ropp uses about a ton of wood fuel per ton of ore, the shaft furnace was said to require only 3 cwts., and the cost of working to be about 8*s.* a ton as compared with £2 with the Ropp. The above description applies to the shaft furnaces in their experimental stage, as built at the Upper Works, and no doubt improvements have been made in those recently built at the new Mundic Works.

During the last half-year 15,628 tons of low-grade sulphide ore have been treated at these new works, and have yielded 7,616 ozs. 8 dwts. of gold, an average of 9·74 dwts. per ton. A second section of these works, which will double their capacity, is now being completed. Electric locomotives are being introduced to bring the ore to them.

CENTRAL POWER STATION.

Compressed air is used largely for driving machine rock-drills and hoisting engines in the mine. The main air compressor made by Richard Schram & Co. is compound and condensing, with high-pressure cylinder 16 ins. in diameter, low-pressure 26 ins., stroke 2 ft. 6 ins., and two air cylinders, each 18 ins. in diameter.

The air is delivered at 75 lbs. per sq. in. pressure. The inlet air is drawn from below the engine-room at a depth of 3 to 4 ft. up a tube with a bell-mouthed end



GENERAL VIEW OF THE MOUNT MORGAN MINE

attached to the air cylinder. In this sunny climate this little arrangement makes a difference of 25 degs. F. in the temperature of the inlet air.

There is a duplicate air compressor with one steam cylinder, 18 ins. diameter by 3 ft. 3 ins. stroke, driving through a crank shaft which carries a flywheel two air cylinders, each 11 ins. diameter by 3 ft. 9 ins. stroke, one on each side of the steam cylinder.

The air passes from the engines into two receivers placed outside the engine-house, having cubical capacities of 350 cub. ft. and 275 cub. ft. Thence it is conveyed a maximum distance of 2,000 ft., and to an elevation of 270 ft. above the receivers up the hill through 6-in. pipes. The loss in pressure at the far end is only 3 to 4 lbs. per square inch. The large size of the pipes reduces friction. At first cast-iron pipes with lead joints were used throughout, laid 12 inches below the surface with ordinary expansion joints at intervals. There was some trouble with leaking joints owing to cracks in the lead near the compressor end, and therefore for the first 100 feet from this end wrought-iron pipes with screw-cap joints have been substituted. There has been no trouble since.

Under the same roof as the two air-compressors are three pumping engines: a large one, of the Worthington type, lifting 500,000 gallons daily a height of 270 ft., and two smaller Cameron pumps; also four dynamos for electric lighting, driven through belting with an intermediate shaft below the floor by three compound condensing engines, each of 60 i.h.p. Two are run at a time, the third being kept as a spare. Three of the dynamos are Brush machines, supplying current to arc lamps of 1000-candle power, and the fourth a Crompton equal to 112 incandescent lamps of 16-candle power each.

The pumping engine raises the water to a reservoir, which has been made high up the hill above the ore treatment works. When the water in this reservoir rises to a certain height it brings a floating metal plate into contact with two brass stops connected with wires to some Leclanche cells in the engine-house, and thus completes the electric circuit, and rings a bell which warns the engineman.

To condense the exhaust steam from all these engines there is a surface condenser, with two air pumps and a jet condenser; and in the unlikely event of a breakdown of both of these, the pipes are arranged so that the exhaust steam can be blown off into the atmosphere.

The steam is raised in three Babcock & Wilcox water-tube boilers at 140 lbs. per sq. in.

A log book is kept, in which is entered the volume of air at atmospheric temperature and pressure produced each shift, calculated from the number of strokes of the engines; the volume of water pumped; the name of the engineman and fireman each shift; the duration and cause of any stoppage or variation; the consumption of stores, oil, packing, etc., and particulars of the running of the dynamos and their driving engines. The condition of the machinery and all the arrangements testify to the efficient superintendence of the mechanical engineer, Mr. James Hirst, whose able guidance added much to the interest of the writer when seeing this Central power station.

The uniform courtesy and intelligence of the officials contribute much to the pleasure of the visitor. The writer, after a varied experience of visits to mines in different parts of the world, was struck by the keen interest in their work displayed by many of the officials and by their genuine regard for the prosperity of their great mine. An admirable spirit seems to pervade the whole staff.

H. J. Bulman.

The Modern Practice of Cyaniding.

By Capt. C. C. LONGRIDGE, M.Inst.M.E., M.I.Mech.E., etc.,
Consulting Mining Engineer.

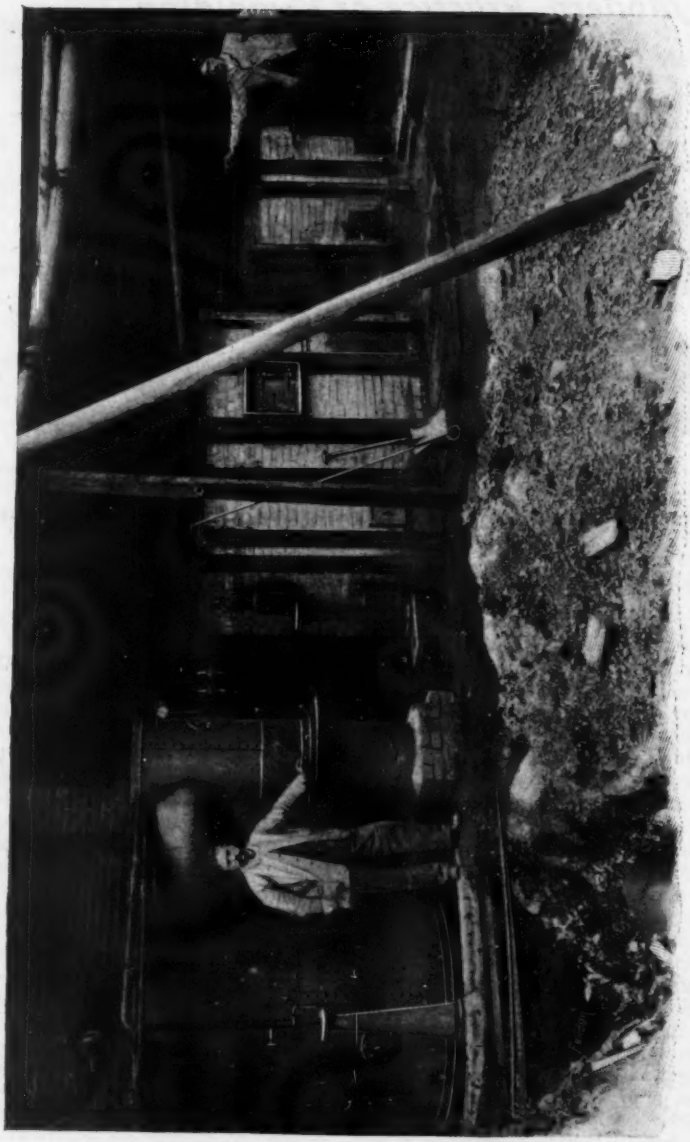
Captain Cecil Clement Longridge was born at Tynemouth, Northumberland, in 1853. His connection with mining began at a very early date; but it was only after his retirement to private practice, as a Consulting Engineer, that he was able to devote his attention chiefly to this industry. His practical experience extends to India, Siam, Straits Settlements, South America, North Africa, Italy, Sicily, Spain, France, Germany, Norway and Sweden, &c.; but his thorough knowledge of mining in other parts of the world is sufficiently evinced by his contributions to the Press. In conjunction with Mr. G. T. Holloway, Analytical Chemist, he patented a new and successful method of extracting gold from auriferous antimony ores, and of smelting the same by producer gas in the Longridge Continuous Furnace.

Captain Longridge is a member of several Mining and Engineering Societies, and the author of several publications on mining and metallurgy. He was, until lately, Consulting Engineer to the Goldfields of Matabeleland, but is now in independent practice at Swan House, Copthall Avenue.

The student of antiquity will find, in embryo at least, most methods of modern gold-recovery. The washing and hydraulicing of alluvial gold, the crushing and amalgamation of free-milling ores, and the smelting of complex auriferous minerals—all, in more or less crude form, had their prototype in bygone ages. Ancient metallurgy, in fact, left little absolutely new for modern science to discover. One legacy, however, it could not bequeath. Of exact chemical and electrical science it knew little, and in this field of metallurgy the modern *savant* found no footprints to guide him. The extraction of gold, therefore, by chemical means, notably by cyanide of potassium, is a discovery entirely due to the present age.

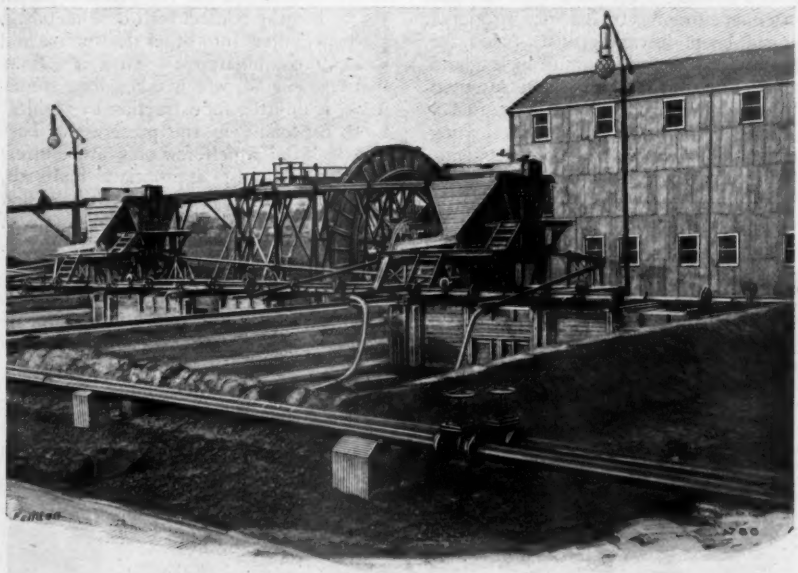
Precisely at what comparatively recent date the properties of cyanogen as a solvent for gold were detected is unknown, but the merits of establishing its commercial value belong to Messrs. McArthur and Forrest. It is true that the inventors' patents of 1887 were subsequently pronounced invalid; but this invalidity was due, not to lack of novelty, but to a technical flaw—the inclusion in the patent of a claim to the use of *any* solution of cyanide, whereby the patentable claim to the use of a *dilute* solution of specified strength was rendered invalid.

From the time that the successful inventors introduced their process into metallurgical industry, incessant efforts have been made to increase the percentage and decrease the cost of extraction until, in these respects, the practice of to-day seems near perfection, although its theory still struggles in the arena of conflicting opinions. This anomaly is due chiefly to the complexity and obscurity of the chemical reactions arising from the presence of what are known as cyanicides, or destroyers of the chemical. Theoretically the amount of potassium cyanide required to dissolve 100 ozs. (troy) of gold is, roughly, 4·53 lbs.; but in practice at least 300 lbs. is needed to extract this



TWO SECTIONS OF THE LONGRIDGE CONTINUOUS FURNACE, FIRED BY DAWSON PRODUCER GAS.

amount of gold from 400 tons of tailings. The enormous difference between the theoretical and the actual consumption is due partly to mechanical and physical losses, and partly to the action of cyanicides, for the most part base metals. The presence of certain soluble salts of copper, bismuth, antimony, manganese, arsenic, iron, sulphur, tellurium, as also organic matter, are injurious, and at times fatal to the process.



A TAILINGS WHEEL AND SUMPS AT THE WORKS OF THE CITY AND SUBURBAN GOLD MINING CO., LTD.

Such metals, in varying degree, according to their nature and their physical condition, give rise to alkaline sulphides which not only increase the consumption of cyanide, but also augment the loss of gold. While some ores of a complex character are thus altogether unsuitable, others may be rendered amenable to treatment by means of a preliminary roast.

The number of roasting furnaces on the market is legion.

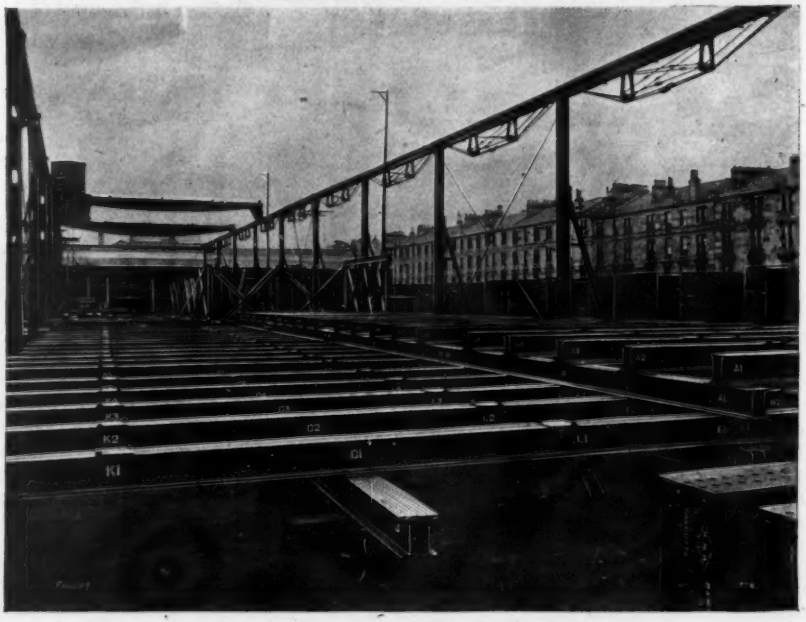
In addition to the reverberatories of the usual constructions, there are automatic hearth furnaces. The most prominent of these are the O'Harra, with certain modifications by Allen & Brown. In this type the ore is gradually and continuously moved through the furnace by a mechanically actuated rabbler. Somewhat similar to these are the Pearce turret furnace and the Brown horseshoe furnace, both of which may be roughly described as long, narrow hearths, built in the form of a circle. These annular furnaces, also, are provided with mechanical contrivances for carrying the ore over the hearth. Other calciners are revolving cylinders with continuous discharge, such as the White-Howell and its imitations; or similar cylinders with intermittent discharge, such as the Bruckner and its variations. The author is of opinion that too little attention has been given to the use of water

gas for roasting purposes. The ease with which the temperature can be regulated is especially valuable for roasting ores containing constituents such as tellurides, arsenicides, etc., the volatilisation of which may cause heavy loss. Some two years ago the author successfully applied producer gas to the firing of his continuous furnace, designed for the smelting and extraction of gold from auriferous antimony ores by the Holloway-Longridge process, and has since suggested the use of gas, as a substitute for solid fuel, in blast furnace smelting.* In America, producer gas has been advantageously used for both drying and roasting, and in England Messrs. Thwaites & Denny have patented an ore-roasting furnace fired by gas fuel.

The operation of roasting or calcining is designed to expel the sulphur, arsenic, antimony, and other volatile and deleterious substances, and to oxidise other metals present, so as to leave, as far as possible, nothing but metallic gold to combine with the cyanide.

Apart, however, from the chemical constitution of the ore in which the gold is lodged, the physical condition of the precious metal itself largely affects the suitability of the ore for cyaniding. Coarse and nuggety gold is unsuitable for extraction by this means. For, although a dilute solution of cyanide has a preferential or selective action for the precious metal, yet, in lengthy contact with base metals, it gradually enters into other destructive and wasteful combinations. Thus it follows that coarse gold, which takes long to dissolve, is unfitted for extraction by cyanide, more especially in the presence of base metals, from which few ores are entirely free. The most appropriate materials, therefore, are crushed ores, tailings, and slimes, containing gold in a fine state of

* *The Engineer*, August 17th, 1900.



SETS OF GIRDERS, CONSTRUCTED BY MESSRS. P. AND W. MACLELLAN, LTD., GLASGOW, TO BE USED FOR MOUNTING CYANIDE VATS.

division, and, as far as possible, free from deleterious matter.

There is about the chemistry of the process another and rather remarkable feature — namely, that the presence of some substance with a sufficiently strong affinity to unite with the potassium is necessary for the dissolution of gold in potassium cyanide, and in its absence no gold is dissolved. The usual agent is oxygen, either in a free state or loosely combined.* The equation: $4\,Au + 8\,KCy + O_2 + 2O\,H_2 = 4\,Au, Cy, KCy + 4\,KOH$, demonstrates that the ratio of gold dissolved to the oxygen required is 198 to 8. Thus in working with low-grade ores and weak solutions the materials usually carry enough oxygen for the purpose, and it is only with rich ores and stronger solutions that the use of an oxydising agent may sometimes be a distinct advantage.

The actual operation of cyaniding is simple in detail. The ore is first closely sorted above ground, the proportion of waste varying inversely with the width of the lode, but rarely exceeding 50 per cent. of the material raised. For sorting, grizzlies, trommels, sorting floors, bumping tables, travelling belts, rotary tables, and the like are used. The sorted ore is then broken, in one or two stages, to convenient size by rock breakers. These are of the reciprocating type, such as the Blake or the Wells, or of the gyratory pattern, such as the Gates crusher. The latter are well adapted to large outputs, and are worked with less vibration, but they suffer more from wear and tear than the reciprocating crushers. The sorting and breaking plant is arranged either on the mine head-gear or in a separate erection, rarely in the mill.

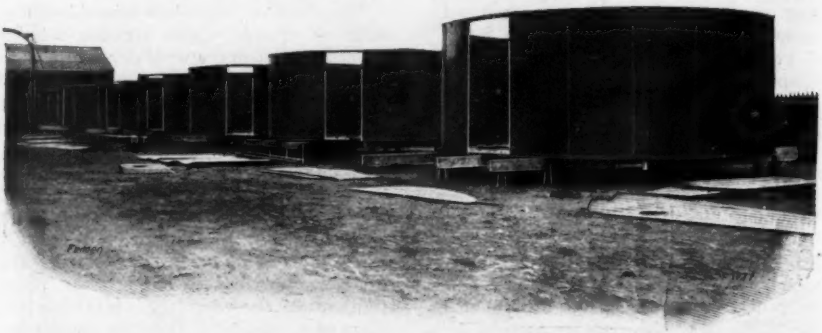
When the ore is broken, it is mechanically transferred from the ore bins to the mill for wet crushing by stamps; less frequently to stamps or rolls for dry crushing, for which purpose also Messrs. Easton, Anderson & Goolden have introduced their Niagara crusher. To promote rapid crushing in the battery, the weight of the stamps is mostly placed to 1,000 or even 1,250 lbs., with a low discharge of 3 to 4 ins., and a speed of 90 to 100 drops per minute. Under these conditions 5 to 6 tons of ore per stamp in twenty-four hours is, in many places, a common output. Mortar liners and false bottoms are in general use; internal amalgamating plates are rather in disfavour, the coarse gold, if present, being recovered on outside plates. The stamps are almost invariably arranged in batteries of five, the frames being largely of the reversed knee pattern. The motive power may be steam, water, or electricity. Where rolls are employed, the reduction is gradual, the material being passed through two or more sets of rolls. After the removal of the coarse gold by amalgamation, the residue or tailings are prepared for the cyaniding vats.

Questions on which considerable difference of opinion exists are the relative advantages of wet and of dry crushing as systems, and the comparative claims of stamps and of rolls as crushers. Without separating these questions, or going too deeply into the why and wherefore, it may be said that, where water is available, hard ores, containing free, coarse gold, are preferably treated by wet stamping, with amalgamation and cyaniding of the tailings, which must be so handled as to reach the cyaniding vats in a leachable state. If, on the contrary, the water supply is inadequate, such ores may be dry crushed by stamps —rolls are less suitable for hard ores—and, after the coarse gold is separated, the residue may be cyanided. Certain soft, oxidised ores, also talcose ore liable to slime, may advantageously be dry stamped. Considered generally as systems of reduction, wet crushing, in the author's opinion, is preferable to dry. For although advocates of dry reduction, mostly by rolls or ball-mills, may, with some reason, urge lower capital outlay in plant and water supply; easier handling of the ore for cyaniding; and fewer slimes;—yet, against these advantages may be advanced, with even stronger force, the cost and labour of drying the ore preparatory to crushing; the lower output; the heavier wear and tear of the plant; the necessity of mechanically separating the coarse gold, if present; and, in rolls, the development of certain

* Gold in ores can be dissolved by potassium cyanide, in the absence of oxygen, if the ore contains basic ferric sulphate, a common constituent, when oxidised pyrites is present.

defects difficult to remedy. Again, in the case of either roll or ball-mills, there is the disadvantage of interdependence of the plant units. For, while, short of a breakdown in the prime mover, each unit of a stamp battery has its independent output, that of the roll or ball-mill so depends on the mutual co-operation of the breaker, the screens, and the rolls or balls, as to cease if a breakdown occurs in any one portion of the mill.

Omitting, however, further discussion of a purely technical matter, we pass on to consider the application of the cyanide process. The general routine is as follows:—The crushed material or pulp is carefully sampled, and then charged into the lixiviating or percolating vats. The transfer



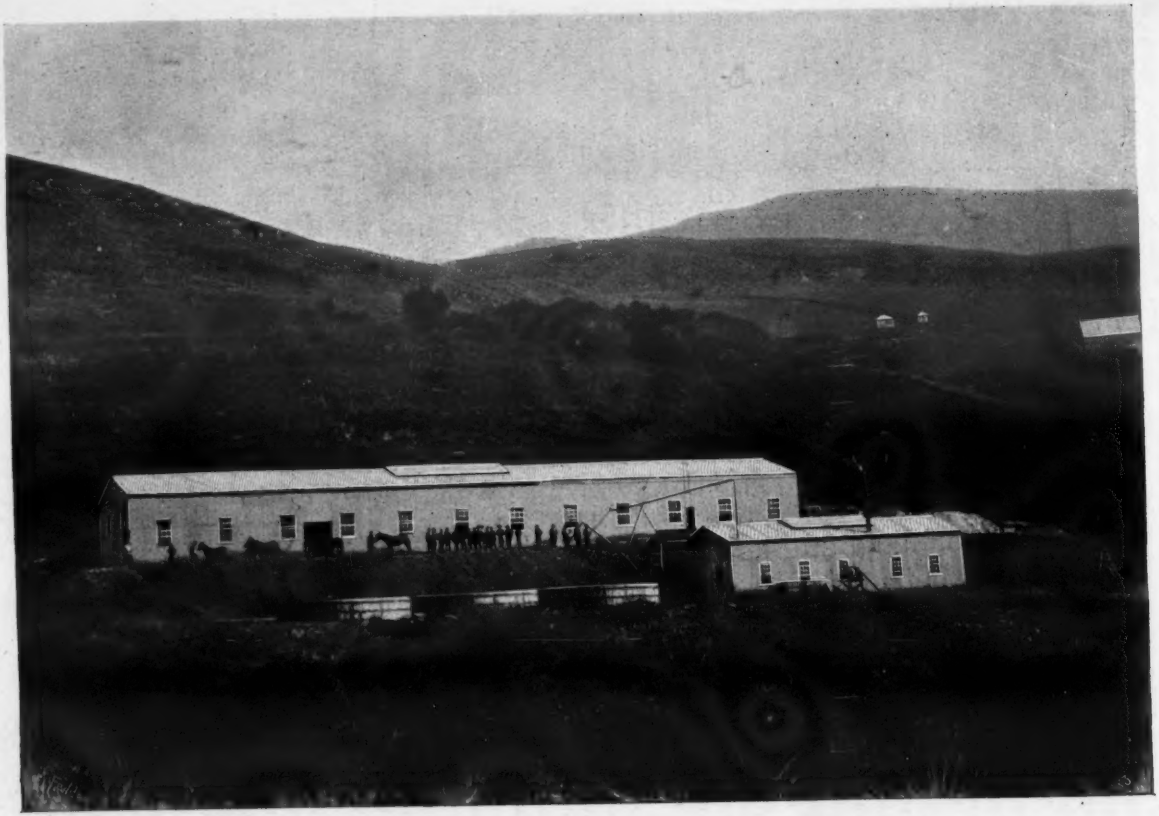
VIEW OF CYANIDE LEACHING VATS, ERECTED FOR INSPECTION, AT THE WORKS OF P. AND W. MACLELLAN, LTD., GLASGOW.

of the pulp from the mill to the cyanide works is facilitated by numerous mechanical devices, such as elevating wheels, endless-rope-driven trams, etc. If the samples show the presence of acids, these are washed away by fresh water, or, if necessary, their effect is neutralised by an alkaline wash of caustic soda or lime. These in turn are sometimes carried off by a second water wash. The cyanide solutions are now run on, in two or more applications of varying strength, and when these have been drawn off, the last traces are removed by water washes.

Although the process appears simple and straightforward, every step has been beset with technical difficulties that have required much skill and research to overcome. Even how to prepare the pulverised material for the operation of leaching has involved many costly experiments. This preparation consists in separating the coarse particles or "sands" from the fine clayey residues, technically designated "slimes." It is now accomplished either by what is styled "intermediate," or by what is termed "direct," filling of the cyaniding or leaching tanks. In the former method, the raw material, crushed ore or tailings, is led into intermediate or settling tanks previously filled with water.

In this medium the sands settle, while the slimes drain off with the overflow. Even distribution of the material throughout the tank is effected by hoses or by automatic distributors mostly of the revolving type. When the vats are full the water is drained off, and the sands discharged through a bottom door into the cyaniding tanks, preferably located directly beneath the settling vats. On the other hand, the direct method of filling consists in separating the slimes from the sands by spitzkasten, spitzluten or hydraulic classifiers, and then hosing the sands with a certain proportion of slimes direct into the cyaniding vats. Various advantages are claimed for either system, but the choice largely depends on whether the increased extraction obtained by freer aeration of the pulp and its better mixing by the operation of intermediate filling offsets the additional labour involved.

The tanks, or vats, or percolators used



THE ORIGINAL CYANIDE PLANT ON FRANKFURT FARM, LISBON-BERLYN GOLD-MINING CO., LTD., ERECTED IN 1894 BY MR. A. C. HODGE, M.E.

for the above operation have been made of several materials, such as brick, concrete, wood, iron, steel, used either above or in combination with one another. Concrete and brick vats, however, are now obsolete, and wood rapidly becoming so.

Iron or steel are therefore the favourite materials, the plates being riveted together, and the whole mounted on stone foundations or on girder structures.

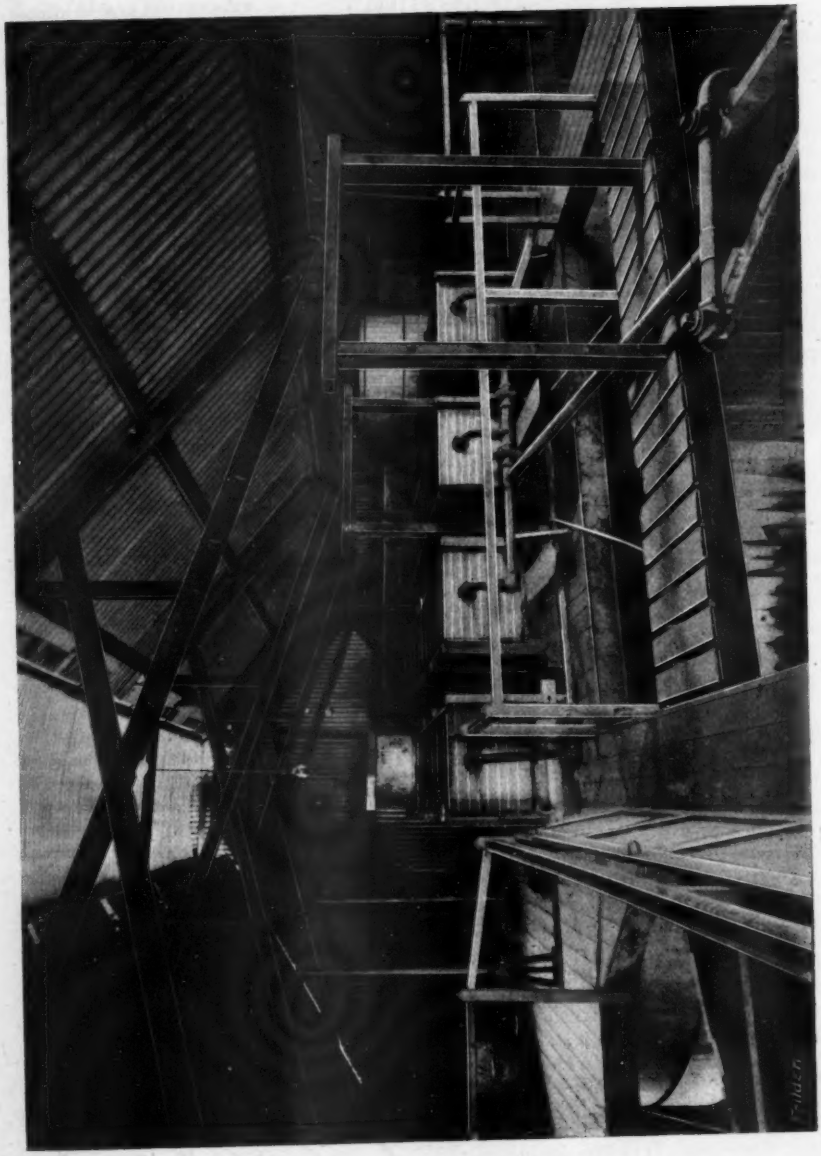
When the cyaniding vats have been filled by either methods, the so-called "strong" solution of cyanide, which may contain from 0·1 to 0·5 per cent. KCy, is poured on to the material, usually to the extent of about 33 per cent. of the amount of ore in the vats. The material is then allowed to soak for one or two hours. Then a portion of the solution which has become weakened by the moisture originally contained in the sands is drawn off, and more "strong" solution is added, until the whole liquid is raised to standard strength. The material is then soaked for about six hours, while the gold dissolves. This completed, percolation or draining follows. As soon as the auriferous liquor ceases to flow, the leached sands are washed with "weak" cyanide solution containing from 0·02 to 0·2 per cent. of KCy. The quantity, which is previously determined by laboratory tests, is commonly from one-half to double the amount of the "strong" solution. Although the percentages of cyanide in the "strong" and in the "weak" solutions are usually those here stated, yet, in certain rarer cases, a "strong" solution may contain even less than 0·1 per cent. KCy. In such instances the "weak" solution will be correspondingly diluted, while the time of leaching must be prolonged.

When tests of the outflowing liquid show that no further extraction of gold is taking place, water is poured on to the top of the charge, and the contents of the vat are rapidly and thoroughly washed. The full amount of water required for this purpose is about one-third of the weight of the sands; but, in practice, for certain reasons, this amount is frequently reduced to one-tenth or one-twentieth. When the washing is completed, the tanks are emptied and again refilled. Slimes, by reason of their imperviousness, are treated somewhat differently.

First, they are run into tanks, where settling is accelerated by the addition of powdered caustic lime. Leaching then follows, accompanied with agitation and aeration, by revolving stirrers, compressed air, or more commonly by centrifugal pumps. When the dissolution of the gold is finished the slimes are allowed to settle and the auriferous solution decanted off.

A process said to be successfully adopted in Western Australia consists in charging the slimes into filter-presses, through which cyanide solution is forced. The method can scarcely be cheap or free from mechanical difficulties.

The next operation to be described is the recovery of the dissolved gold from the various cyanide solutions. These, according to their respective strengths, are led off into extracting boxes, where the precious metal is precipitated, either by the electrolytic process of Siemens-Halske, or by means of zinc shavings, dust or flume, although attempts have been made to replace zinc by carbon, aluminium, sodium, amalgam, etc. For precipitation by zinc, wooden boxes are mostly used, though iron has proved an excellent substitute, being more durable and less likely to leak. The boxes are so constructed that the inflowing auriferous solution passes successively over and under the several partitions that carry the screens holding the zinc shavings. These should be cut so fine as to freely ignite on the application of a light. To prevent contamination of the gold slimes, the zinc should be free from lead, in no case containing more than 1½ per cent. of that metal. The consumption of zinc is about ¼ lb. per ton of ore treated. For electrical precipitation the boxes are of rather larger size, the lead cathode being generally in the form of strips and shavings; mercury wells also have been introduced. The electrolytic process is pre-eminently adapted to deal with extremely weak solutions, such as are obtained in treating slimes. From time to time a clean-up takes place, when the gold precipitates are collected, filtered, dried, smelted and



A SET OF EXTRACTOR BOXES AT THE NEW HERIOT MINE.

refined to bullion; the use of glass as a primary flux has been recommended for economy and efficiency. The cyanide solutions from the extractors flow into the sumps, and, after being fortified to their proper strength, are re-used.

The cost of cyaniding naturally depends upon the tonnage treated, the price and consumption of chemicals, the cost of labour, power, water, etc. But the cheapness of the process, under up-to-date management, will be duly appreciated when it is stated that the expenditure at the Geldenhuis Deep is only about 2*s.* per ton treated. The actual costs of extraction may often be reduced by careful attention to the bye-products formed, especially where acid or partly oxidised ores are treated. These bye-products are the precipitates from the settlement of the precipitated liquors or from the filtration of the effluents from the zinc boxes, the skimmings of the melting-pot, and the refinery residue from the cupellation of the bullion.

Every day sees fresh modifications of the original process, and among these may be mentioned (1) the Pelatan-Clerici process, in which material sufficiently rich to bear the extra cost of power and chemicals is agitated with cyanide solution and salt, and the gold amalgamated with mercury under the influence of an electric current. (2) The Kendall system, which employs sodium dioxide as an aërating agent, but of which no working data are available. (3) The Park-Whitaker method, for treating cupriferous ores and concentrates by a chloridising roast, and by the after-removal of the soluble copper chlorides. (4) The Hannay electro-cyanide process, very similar to the Pelatan-Clerici. (5) The Molloy, in which sodium and potassium amalgam is used for recovering the gold. (6) The Pielsticker precipitation by an electric current. (7) The Moldenhauer use of aluminium in place of zinc. (8) The Johnston adoption of carbon in lieu of the same material. (9) The Sulman-Vautin and the Sulman-Teed accelerated dissolution of gold by the use of cyanogen-bromide. (10) The Mulholland bromide process. (11) The double treatment introduced in South Africa, in which additional gold is recovered by submitting the washed residues of the first treatment to further leaching in a second tier of vats. (12) The Diehl system, a variation of the Sulman-Teed, with special methods of ore-dressing.

As the employment of any of these systems involves the use of a deadly chemical, it may be worth while stating that cases of poisoning at cyanide mills rarely occur. Several antidotes are in use. If the poisoning is due to the inhalation of prussic acid, the patient should inhale small quantities of ammonia, ether, or chlorine gas, which latter may be quickly made by sprinkling a little bleaching powder on a cloth moistened with acetic acid. Where the cyanide has been imbibed, the injection of hydrogen peroxide in solution is said to be successful when no excessive amount of the poison has been taken; for, as sufficient peroxide must be given to convert the whole of the cyanide into oxamide, it follows that, if a large amount of the poison has been drunk, the amount of oxamide formed may itself be fatal. Another reported remedy, discovered in 1893 by Dr. Johann Antal, a Hungarian toxicologist, is an injection of nitrate of cobalt. In reference to this, Dr. J. C. Fraser, not long ago in the *South Australian*, stated:—"When the symptoms indicate that the poison has been absorbed in considerable quantity, hypodermic injection of two to four minims of liquor atropinal sulphates every half-hour may be necessary; but this agent should never be used by laymen, if medical aid is within reach." Where no doctor is available, no time should be lost in placing the patient in a hot bath and applying cold water to the back and neck. Vomiting should be induced by emetics, such as a dessert-spoonful of mustard in a pint of warm water, and after this is effected, a dose of freshly precipitated carbonate of iron, made by mixing equal quantities of carbonate of sodium and sulphate of iron, may be administered.

C. C. Fergus.

Gold-Mining Machinery.

By PHILIP R. BJÖRLING.

(A Portrait and Biography of Mr. Björling appeared on page 179, Vol. I.)

THE treatment of ore containing gold differs greatly in the various classes of ore taken from the mines in different parts of the world; in fact, even in the lodes in the same locality.

The ore, as received from the mine, is usually in large pieces, which require to be broken up before the fine crushing commences.

The best method adapted for the purpose is by

ORE CRUSHERS.

BLAKE'S ORE CRUSHER.

This is a well-known machine, which consists of a strong, cast-iron frame or body having at one end a fixed jaw, against which works a moving jaw; this latter receives its motion by means of a connecting-rod and two toggles. Messrs. Fraser & Chalmers' latest design is illustrated in Fig. 1. In this case the body casting is strengthened by means of two massive tie-bolts secured at one end by cotters, and at the other, the front end, by nuts, so as to take part of the strain off the cast-iron. The connecting-rod is actuated by an eccentric on the fly-wheel shaft; this shaft is driven by a belt on a pulley, and a heavy fly-wheel is keyed on each end of the shaft to procure an even and steady motion. The moving jaw is usually brought back to its normal position by means of a long bolt and india-rubber buffer spring; some makers employ a steel spring instead of the india-rubber one.

Some engineers prefer a body made of rolled steel, instead of cast-iron, when the machinery has to be transported up new countries by bullocks or mules, and over most difficult rivers by boats. One of the steel-framed crushers, manufactured by Messrs. Robey & Co., is shown in Fig. 2. This machine is fitted with a steel spring, as is clearly shown in the illustration. The moving jaw can be adjusted whilst the machine is at work, so as to reduce the material to any desired size, down to three-eighths of an inch in the large crushers, and one-fourth of an inch in the smaller machines.

Perhaps a more economic machine is

HALL'S PATENT MULTIPLE-ACTION ORE CRUSHER.

This crusher has the moving jaw divided into two parts, arranged so that when one half is working forward the other is returning, consequently only one-

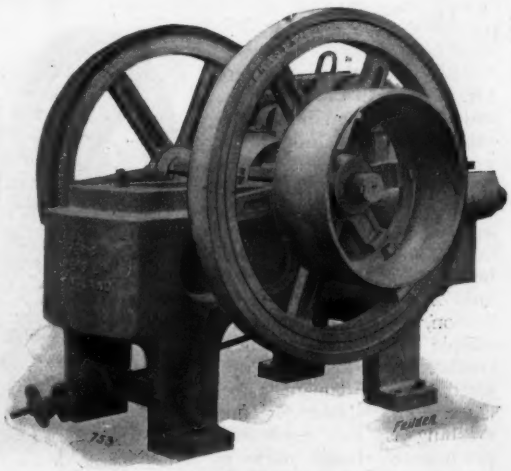


FIG. 1.—BLAKE'S ORE CRUSHER.

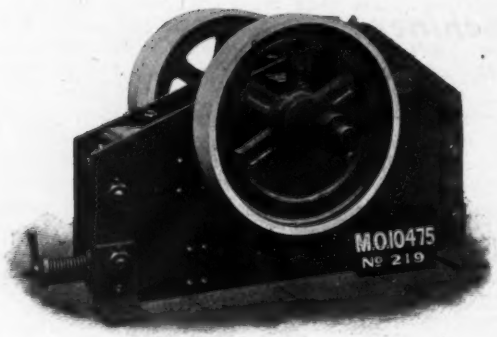


FIG. 2.—STEEL-FRAMED CRUSHER.

half the power is required to do the same amount of work in the same time. No india-rubber spring buffer or steel volute springs are required, for the forward motion of one moving jaw draws the other jaw back. There was a slight defect in this machine, namely, that there existed a slight vibration in the eccentric or fly-wheel shaft; but that has been overcome by the introduction of a central bearing between the two jaws, which can be clearly seen in Fig. 3.

THE "SAMSON" ORE CRUSHER.

This is another variety of Mr. C. E. Hall's ore crushers, which is illustrated in sectional elevation Fig. 4. From this it will be seen that it is similar in action to the "Dodge" crusher—that is, that the moving jaw does the breaking up of the ore at the top, and the bottom end of the jaw has only a slight up-and-down motion, so that a more even sample is produced. These crushers are, for hard ore, fitted with "Adamant" steel faces. The speed for fine crushing is 200 revolutions per minute. Large blocks of quartz can be at once reduced to ¼-in. cubes or less, thereby dispensing with crushing rolls, and hence greatly reducing the cost of treating the material. The construction is extremely simple, and consists of a massive frame, sometimes made of steel plates, with a chilled fixed face, secured at one end. Upon the top of this frame are two large Babbitt's metal bearings, in which revolves a steel shaft, with two eccentrics forged thereon, opposite each other. Upon the eccentrics hang two vibrating jaws. The shaft has two fly-wheels and driving pulleys keyed thereon. This arrangement dispenses with the usual connecting-rod common to all other multiple-action ore crushers.

"JELMAN-WEPP" ORE CRUSHERS.

There are, of course, many mechanical motions that have been, and yet are, adopted for crushers; one of these is shown in the Jelman-Wepp crushers, illustrated in sectional elevation Fig. 5. It will be noticed that in this case the toggle-motion plate is dispensed with. If

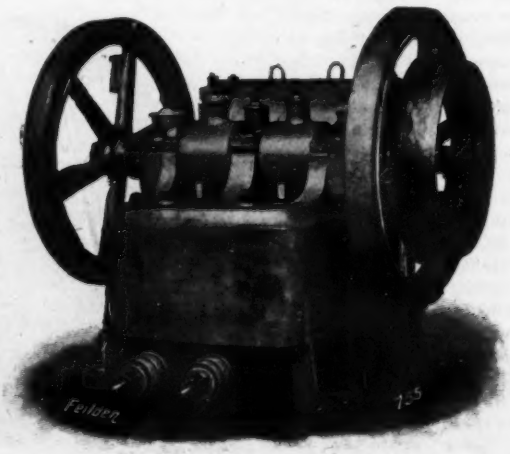


FIG. 3.—MULTIPLE-ACTION ORE CRUSHER.

any extra hard material or any foreign matter, such, for instance, a hammer, should accidentally fall into the crusher, the breaking plate is made of suitable strength, so that it will break before any other part, as it is easily replaced by a new one. The side frames are made of steel plates. The connecting-rods are fitted with gun-metal bushes, and all bearings run with white-metal, and the moving jaw is drawn back with a spring.

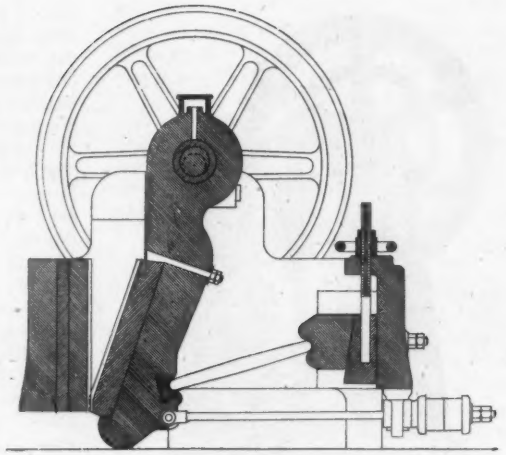


FIG. 4.—"SAMSON" ORE CRUSHER.

A sectional elevation of a Jelman-Wepp crusher with top motion of the moving jaw, similar to a "Dodge" crusher, is illustrated in Fig 6. The distinguishing feature in the action of this crusher is that the rocking jaw is pulled or drawn against the stationary jaw instead of being pushed or driven against it. The latter system, which is that at present universally adopted, requires the fixed or stationary jaw to be enclosed in a very massive frame, forming part of the body of the machine. The stationary jaw is hung on a steel eccentric shaft, which draws the oscillating jaw up to and against the fixed or stationary jaw.

The last two examples of crushers are manufactured by the Thames Mining Machinery Co., Ltd., of London.

All these ore crushers are frequently fitted with a revolving screen, so that an even sample of crushed ore can be produced; all that will not pass through the meshes in the screen are returned to the crusher to be reduced in size till the ore will pass through the screen.

Another crusher well known throughout the mining regions, especially in America, is

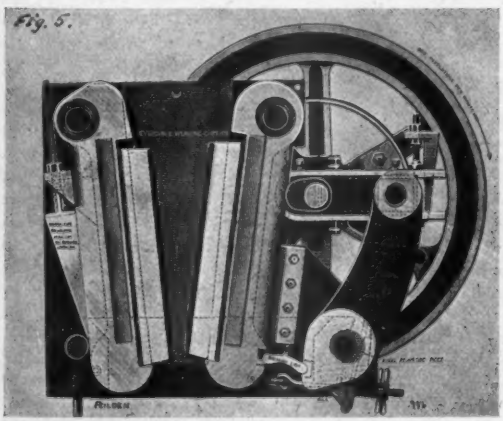


FIG. 5.—"JELMAN-WEPP" ORE CRUSHER.

THE "DODGE" CRUSHER.

It is particularly adapted to concentrating works of moderate capacity, or in large concentrating works for fine crushing below the Blake crusher, to produce a finer and more uniform product for the rollers, as, in leaving the machine, the product is reduced to a finer and more uniform size than can be obtained by the ordinary crushers.

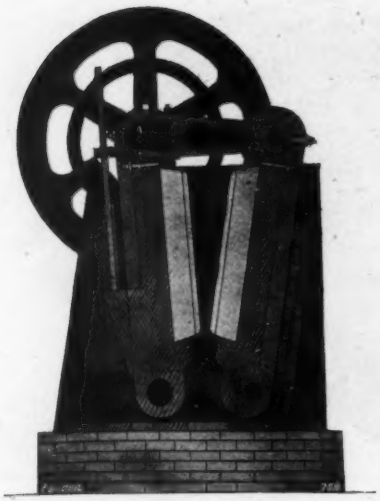


FIG. 6.—SECTIONAL ELEVATION, "JELMAN-WEPF" TOP-MOTION CRUSHER.

Fig. 7 is a sectional elevation, and Fig. 8 a perspective view of one of the Dodge crushers. The principal difference between the Blake and the Dodge crushers is that the movement of the lower part of the jaw is greater than the top in the Blake crusher. When the jaw is open a product of various sizes drops from the machine, whereas in the Dodge the movement is greater at the top of the jaw; the lower part of the jaw remains nearly stationary, and the product in leaving the machine must be of nearly uniform size, determined by the distance the jaw plates are set apart. The means of adjustment are very simple. The jaw shaft rests in movable bearings. To change the size of material crushed it is only necessary to loosen or tighten the screws and place packing blocks on either side of the movable shaft bearings. If for finer crushing, put packing blocks on side of movable bearings toward eccentrics; if coarse crushing, put the packing blocks in front of screws. The screws should always be tight, with lock-nuts set up when crushing.

THE DIRECT-ACTING STEEL ORE CRUSHER.

This crusher is illustrated in Fig. 9. It is a reproduction of a photograph of a 9-in. crusher, one fly-wheel and one cheek having been removed. It will be noticed that the ordinary heavy body casting is dispensed with, and strong steel rods substituted for it. The moving jaw is not vibrated in the usual manner, the power being applied through the cam-shaft and loose jaw holder to the crushing jaw

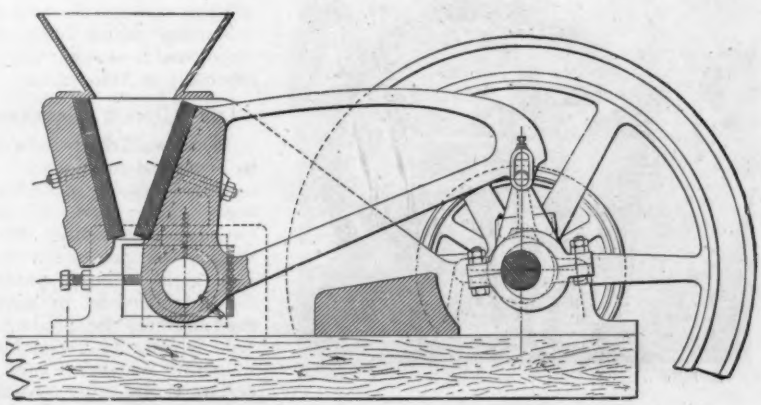


FIG. 7.—THE "DODGE" CRUSHER: SECTIONAL ELEVATION.

direct, without intermediate joints. The loose jaw holder is carried by a rod passing the centre of its face and supported at the ends by rocking levers, hence the throw of the breaking jaw is equal over its whole surface. The eccentric shaft works in bearings fitted with gun-metal steps. The length of opening between the crushing or moving jaw can be easily and quickly varied by altering the length of the tension rods between the standards and fixed jaw. These ore crushers are very suitable for transport up mountains and rough roads, on account of their lightness, and they are very easily repaired if a few spare parts are kept in the stores. This crusher has been patented by Mr. N. G. Kimberley.

Gates' Fine Crushers.

A crusher of this class is illustrated in sectional elevation, Fig. 10. These are of the gyratory type, and were the first crushers of this class. This machine is calculated to take the material which has passed, say, 3-in. ring size, and is capable of reducing same to such size that 90 per cent. or more will pass a one-half screen. The head of this machine, which is very large and only 10 ins. in length, allows of making a cast-iron core or centre, which is fastened permanently on the shaft and has an abrupt taper so that a thin parallel shell may be drawn on to same with bolts, in similar manner that shells are used in Cornish rolls. The shaft or spindle in this machine is suspended, the head being raised and lowered by removing the dust cap on top of the spindle and turning the nut to the suspension screw. The discharging diaphragm is made independent of the frame, and can therefore be shifted while in place so as to discharge in front or either side.

Based on a very hard porphyry screened of all finer than 1½ ins., it will deliver four tons and upwards per hour, 90 per cent. or more of which will pass ¾-in. screen; but by raising the head slightly the machine is capable of so crushing that 90 per cent. or more will pass a ½-in. screen, and, on the material above-mentioned, at the rate of 1½ to 2 tons or more per hour.

To work one of these crushers on the above-mentioned material, which withstands a crushing pressure of 30,000 lbs. or more per square inch, requires from 10 to 15 i.h.p. when working to full capacity.

The "Comet" Rock Crusher.

This crusher is manufactured by Messrs. Fraser & Chalmers, of London and Erith, and is illustrated in sectional elevation Fig. 11. The axis of the upright spindle is not coincident with main axis of the machine, but intersects it in the bearings in the tripod, while the lower end is from ¼ in. to ¾ in. out of centre, depending on size of crusher. This arrangement causes a gyratory motion at the bottom of the spindle, the top of journal being practically stationary, except in the slight motion due to the angularity, which is compensated for by the oscillating box. The spindle, with its fixed crusher-head, is not fastened into the bevel wheel, but free to revolve in it. The crushing is caused by movment of the crusher-head to and from the liner, exactly as in a Blake or other similar crusher with reciprocating jaw motion, and as the entire space around the head is filled with rock the crusher is doing duty at every

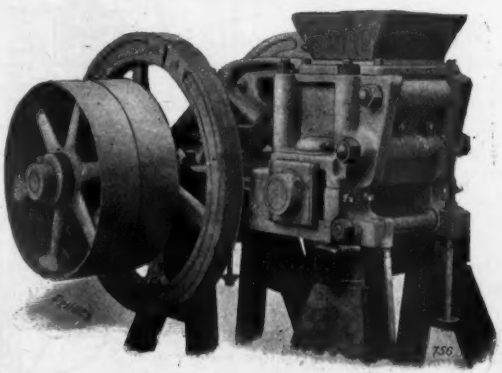


FIG. 8.—THE "DODGE" CRUSHER.

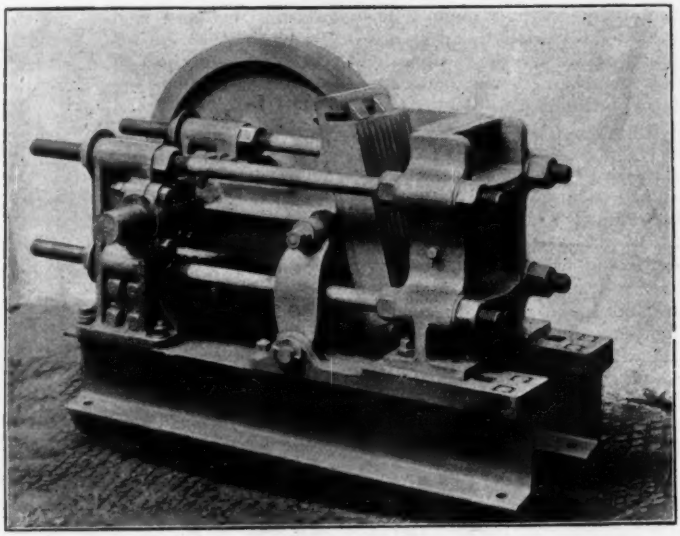


FIG. 9.—DIRECT-ACTING STEEL ORE CRUSHER.

point in revolution of the pulleys and gear. For this reason there is no shock or jar in this machine. There is no grinding action in this machine, as the head does not turn while crushing, although free to do so. The crushed rock drops into the inclined chute and immediately slides out.

The patent adjusting apparatus consists of the main adjustment casting, *A*; the adjusting ram, *C*; drum shaft, *D*; *E* is the chain drum; *F* the bottom chain sheaves; *G*, chain-guide sheave; *H*, pin for the bottom sheave; *J*, adjustment chain. The chains are tightened or slackened by the worm-wheel *K* and worm *L*, which latter is keyed into the worm-shaft *M*. *N* is a cover over the mechanism. *O* is the hand-wheel by means of which the main spindle is lowered. By means of this adjustment the size of the discharge opening

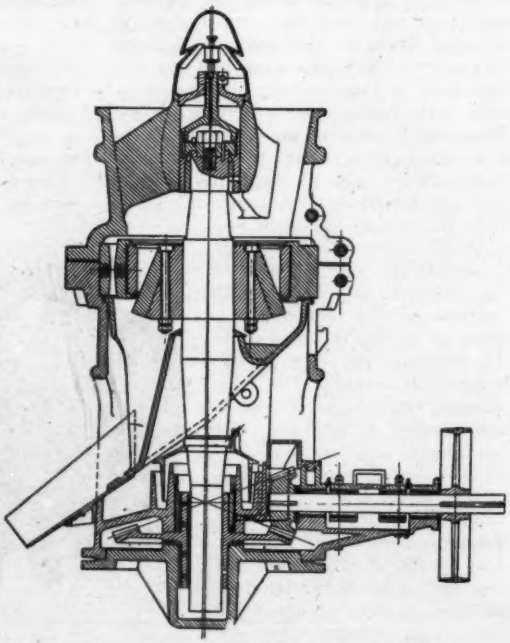


FIG. 10.—GATE'S FINE CRUSHER: SECTIONAL ELEVATION.

between crusher-head and liners can be altered at will without stopping the crusher.

The capacity of this crusher is said to be three times greater than any jaw-crusher, and requires less power in proportion to the amount of ore crushed.

AUTOMATIC ORE FEEDERS.

The most essential features necessary for a good automatic ore feeder are that the hopper must have a large capacity, be simple in construction, and regular and even in delivery.

The principle upon which a thoroughly practical ore feeder ought to be constructed is that of a carrier, and not that of a shaking table; uniform and accurate feeding is not possible upon the latter plan.

The stamps will save more gold than when hand-fed, owing to the regular, steady feeding and even flow of pulp over the plates, with no scouring of plates or loss of amalgam.

THE "ROBEY" ORE FEEDER is illustrated in Fig. 12. The material to be fed being placed in the hopper, the table is made to revolve very slowly, carrying the ore upon its surface out through the front opening of hopper until it comes in contact with a scraper, by which it is pushed over the edge of the table and falls into the mortar-box.

Sometimes the automatic feeder is suspended from the platform, the construction in such cases being slightly modified to suit circumstances.

An ore feeder, bearing the name of THE "TULLOCK" AUTOMATIC ORE FEEDER, is illustrated in Fig. 13. It is not now as

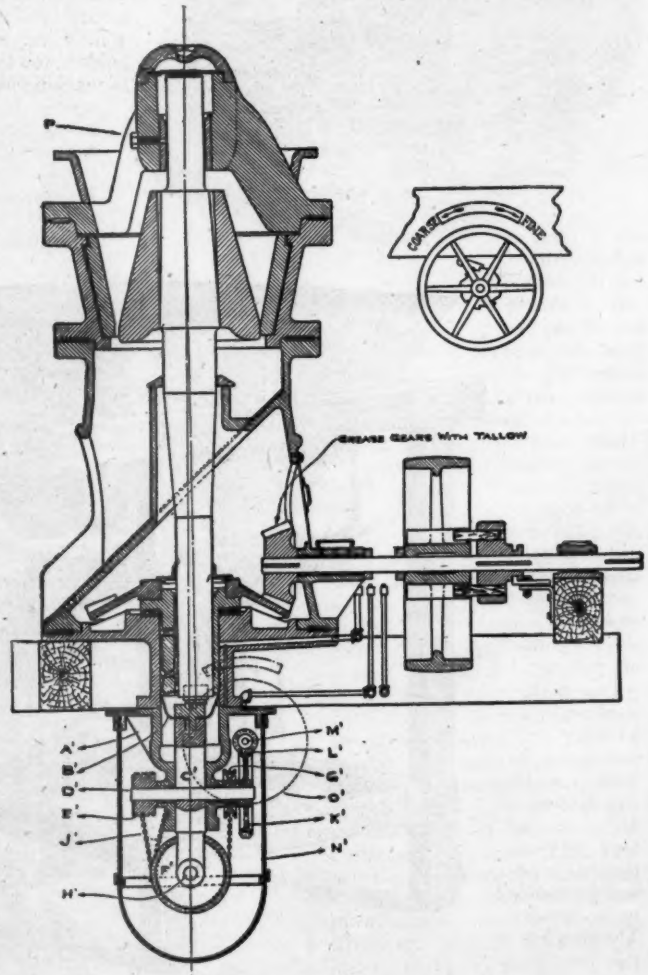


FIG. 11.—THE "COMET" ROCK CRUSHER.

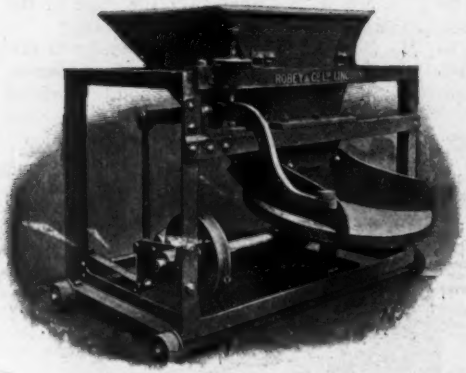


FIG. 12.—THE "ROBEY" ORE FEEDER.

the stamps by means of the vertical rod *I*, the lever *E*, right- and left-hand screws *N*, coupling *F*, lever *H*, and rocking shaft *D*; an adjustment can be had by the handle *G*. The tray *B* is suspended by the three rods *C*, *C* and *M*. The whole feeder runs on the rollers secured at the bottom of the wood framing. The feeder stands 4 ft. 6 ins. high; 3 ft. 6 ins. wide. The hopper holds 1,500 lbs. of ore. Weight of machine 600 lbs.

much used as in former times, for the reason we have already stated, namely, that the feed motion is obtained partly by shaking. These feeders are direct-acting, the back of the hopper *A* is provided with an adjustable scraper, and at each motion of the tray *B* a portion of the ore is scraped forward to the battery. It makes no difference if the ore is wet or dry; it will feed everything that has consistency enough to be scraped. The shaking of the tray *B* is obtained from

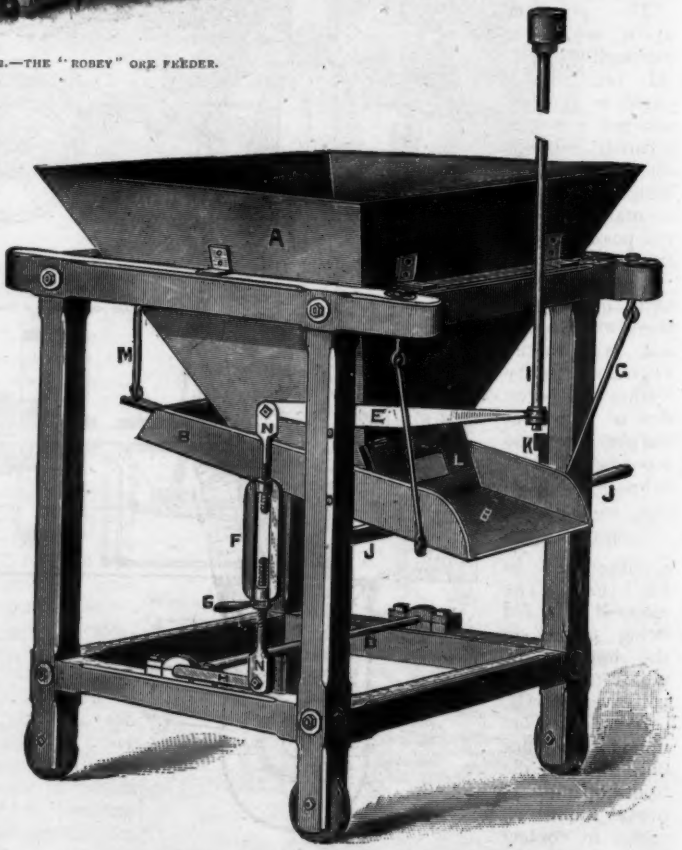


FIG. 13.—THE "TULLOCK" AUTOMATIC ORE FEEDER.

THE "CHALLENGE" AUTOMATIC ORE FEEDER,

as made by Messrs. Fraser & Chalmers, is illustrated in Fig. 14. This feeder can be used for either wet or dry ores, but is especially good on very wet ore. Its operation is simple and unfailing. The cast-iron plate below the hopper, and placed at an angle, is rotated by bevel gears, which in turn are movable by an ingenious friction feed, motion being varied according to the blow received from the tappet on the rod. At each partial rotation a small quantity of ore is scraped off by the stationary wings resting on the plate.

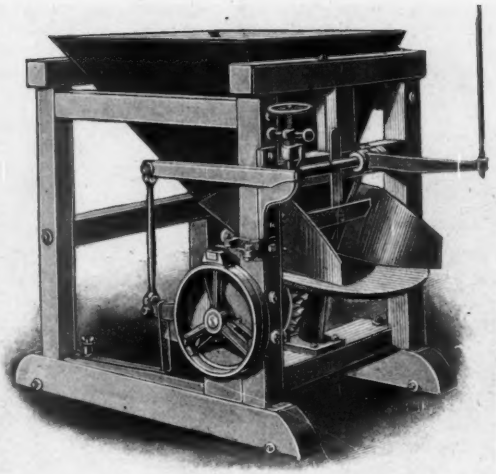


FIG. 14.—THE "CHALLENGE" AUTOMATIC ORE FEEDER.

The "Challenge" Automatic Feeder manufactured by Messrs. Edward Chester & Co., Ltd., is similar to the last-mentioned machine. It is illustrated in Fig. 15. These feeders are sometimes furnished with a false steel wearing-plate, if required, which can be replaced as the surface of the plate wears.

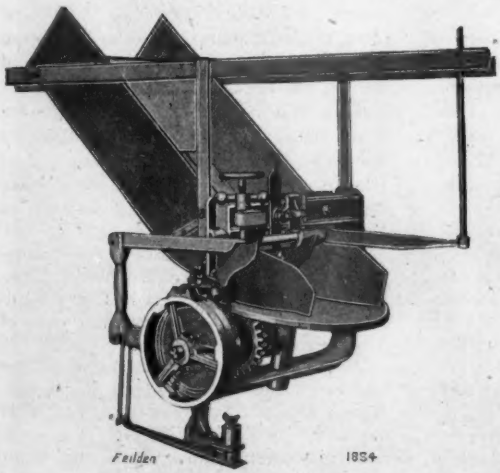


FIG. 15.—AUTOMATIC ORE FEEDER, BY EDWARD CHESTER AND CO., LTD.

They are suspended from knee-beams, therefore it is much easier to get at the working parts, and it allows a free passage behind the stamps; moreover, the feed of ore can be better regulated by the direct inclined chute attached to the bin-gate.

STAMP BATTERIES.

In Gold Milling and some fine concentrating works, stamps are used for the final crushing of the ore. Though a simple form of machine, there is much greater difference in the results of differently constructed stamp batteries than inexperienced men would anticipate. The form of mortar and cams, the material used for the stems, shoes, dies, and the placing of cam-shaft and guides, all exert influences of greater or less importance, and experience is alone the safe guide in such matters. The stamps are most suitable for wet crushing. They are simple to keep in order; easy of repair by an ordinary blacksmith; generally

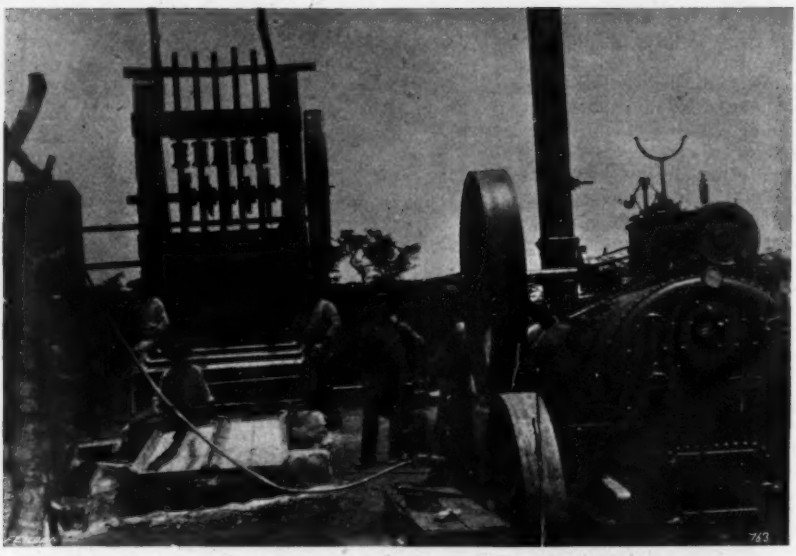


FIG. 16.—BECHUANALAND EXPLORATION CO. 5-STAMP BATTERY, HARLEY HILLS, MASHONALAND. THE FIRST BATTERY IN MASHONALAND, MADE BY THE SANDYCROFT FOUNDRY AND ENGINE WORKS CO., LTD., CHESTER.

understood; capable of almost constant running, and of being stopped, a few stamps at a time, for repairs, so as not to delay a whole mill.

The first stamp battery erected in Mashonaland is illustrated in Fig. 16; it was built and erected by the Sandycroft Foundry & Engine Works Co., Ltd., near Chester, who are, we believe, one of the largest manufacturers of this class of machinery in this country. It was put up by the Bechuanaland Exploration Co., Hardy Hills. It was afterwards purchased and conveyed up country by that company. It is further interesting to note that, in 1883, 600-lb. stamps were generally used for crushing Rand quartz. In 1884 the falling weight was increased to 750 lbs., and gradually it has crept up to 1,250 lbs., which is now generally considered most suitable.

With regard to the weight of stamps to be used, this will depend to a great extent on the class of material to be dealt with, and the degree of fineness that is required for the class of ore operated on; but for gold ores, a stamp of between 950 lbs. and 1,200 lbs. is usually employed.

One of Messrs. Fraser & Chalmers' most modern stamp batteries is shown in Fig. 17. They were made and erected for the Norseman Gold Mines.

This firm has just supplied an 80-head battery mill to the well-known Sheba Gold-Mining Company, near Barberton, in the Transvaal, and have supplied the largest stamp battery to West Australia.

Fig. 18 is an illustration of the Sandycroft Foundry and Engine Works Company's stand at the late Earl's Court Exhibition, which shows clearly their style of "high-bank" battery.

A 10-head stamp battery, made for and erected in South Africa by Messrs. Bowes Scott & Western, Ltd., of London, is illustrated in Fig. 19. The photograph from which the reproduction has been made was taken at the mine.

Another stamp battery by Messrs. Fraser & Chalmers, Ltd., is illustrated in Fig. 20, as it appears when set up in place and as erected in a wet crushing mill. The counter-shaft is seen behind the main post, and also its driving pulley, with belt. A tightener pulley is seen in place, by which the stamps can be stopped or put in motion without stopping the driving power.

The 10-head stamp battery manufactured by Messrs. Edward Chester & Co., of Renfrew, Scotland, is represented in Fig. 21. The peculiarity of this battery consists in that each set of five stamps is driven independently. The reason why this plan has been adopted is on account of the great saving in time should the stamps have to be stopped, either for changing the shoes, stems, etc., or cleaning up. In the old style of batteries as formerly used in California, the stamps were driven in tens. This, no doubt, was adopted owing to the initial cost being less; but the delay in stopping ten stamps instead of five would swallow up in less than two months the saving in cost. Each set of five stamps is driven by a belt off the main shafting, each belt being kept up to its work by a rack tightener.

A stamp battery embodying several peculiar features is the one which is termed by the makers, Messrs. the Thames Mining Machinery Company, Ltd., the

"Jelman-Wepp Stamp Battery,"

which is illustrated in Fig. 22. We have not had any experience with these batteries; we have seen one at work in the maker's experimental works; however, the inventors say that the great fault in the ordinary stamp batteries is the want of sufficient screening surface through which the crushed ore can at once escape. "In all existing types of stamp batteries," the inventors say, "the stamp descends into a mortar-box, where it crushes the ore between the so-called shoes and dies. At the front of this mortar (or, in some cases, at front and back) is a screen through which the

FIG. 17.—MOST RECENT TYPE OF STAMP BATTERY.

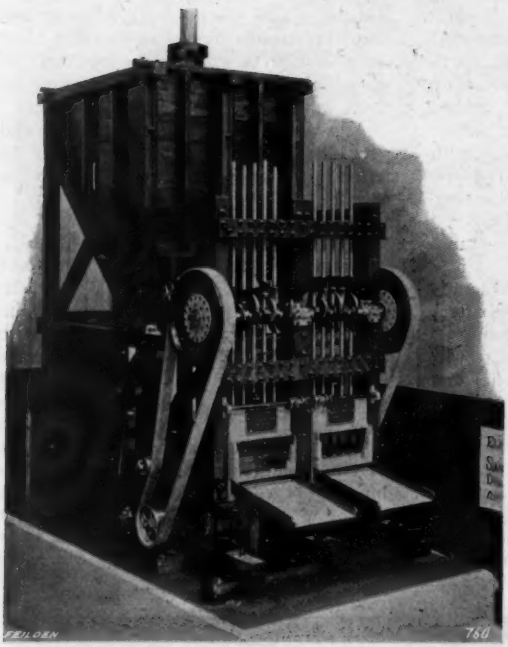


FIG. 18.—"HIGH-BANK" STAMP BATTERY.

ore, crushed by the falling stamp, is supposed and intended to be wholly splashed away. As a matter of fact, only a portion of the crushed ore is so ejected, and the rest, falling back on the die, gets recrushed on the next descent of the stamp, and adds very greatly to the formation of slime. This double crushing, besides the serious disadvantage of producing slime, also detracts from the output efficiency of the battery." To obviate this defect the "Jelman-Wepp" mortar-box is provided with screening surface completely surrounding each stamp. This is accomplished in the following manner:—A mortar-box, similar to that at present used, is adopted, but made much lower. Each stamp is completely surrounded by its own screen, so that when the stamp descends on the die and crushes the ore, so much of the latter as is crushed to the required degree of fineness may be at once splashed or washed away through the all-surrounding screen.

In order to keep the screens clear, a water-pipe, with slits or holes therein, is so arranged on their top edge as to project a stream of water down them, and thus wash away any material which may be adhering to them.

Underneath the top guides are fixed springs, which send the stamp back at a much faster rate than usual, and at the same time a more severe blow is struck on the material to be crushed. The stems work in adjustable guides, which can be set right when the stamps are at work and crushing by means of a worm-spindle. The mortar-box, instead of being of a great height (as is usually the case) and a very high casting, the box for the Jelman-

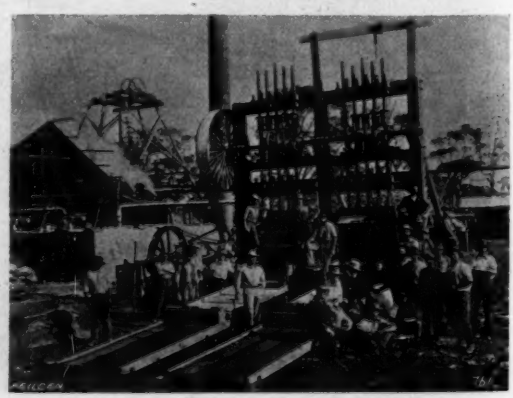


FIG. 19.—STAMP BATTERY BY BOWES SCOTT AND WESTERN, LTD.

Wepp is a low and light casting, and only stands the height of the dies. The upper portion is iron-plate work, which guides the crushed material on to the copper tables, or whatever other machinery may be used. As the dies wear away, half-inch by half-inch, the screen can be dropped half-inches by removing some bars. This always keeps the screen one height above the dies. In ordinary batteries, when 4 ins. or 5 ins. are worn off the dies, they are too much below the lip for further use. When this happens a large quantity of slime is made, and a great deal more water is required to wash the crushed material out of the box; and there is also a much smaller output, owing to the dies being too much below the lip of the mortar-box.

Each stamp has its own independent screen entirely surrounding it, with a screening surface of 1,400 sq. ins. In the ordinary battery there are only 176 sq. ins. of screening surface per stamp. The screens terminate at the level of the top or upper lip of the mortar-box, and do not extend down into it. By this means the wash inside the mortar-box is not interfered with, but allowed to travel from end to end.

It is claimed for this battery that it requires less water than any other, for that it has larger screening area, the sand or crushed ore is more easily and more rapidly got rid of, and that the lowering of the lip of the mortar-box, by removing the bars, renders the washing out of the crushed ore a much lighter job.

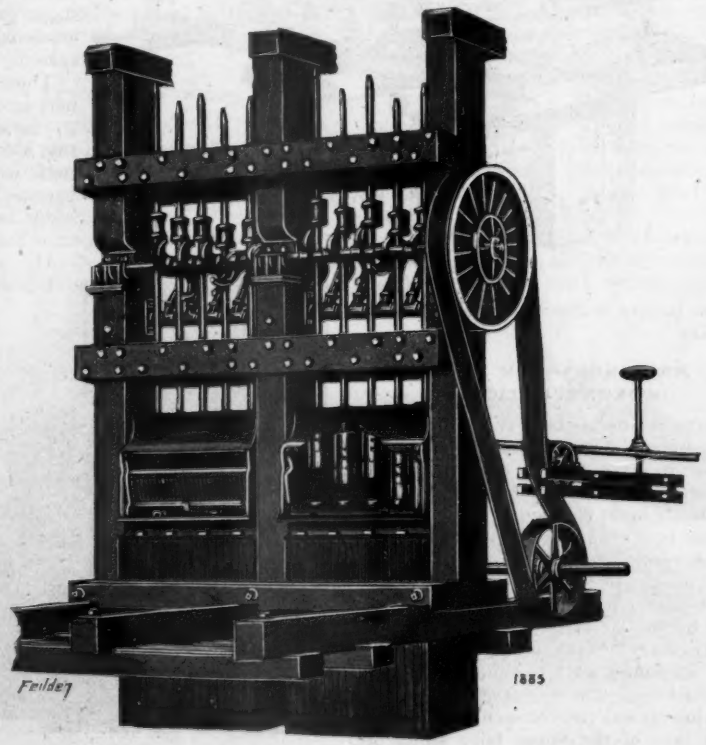


FIG. 20.—STAMP BATTERY BY FRASER AND CHALMERS, LTD.

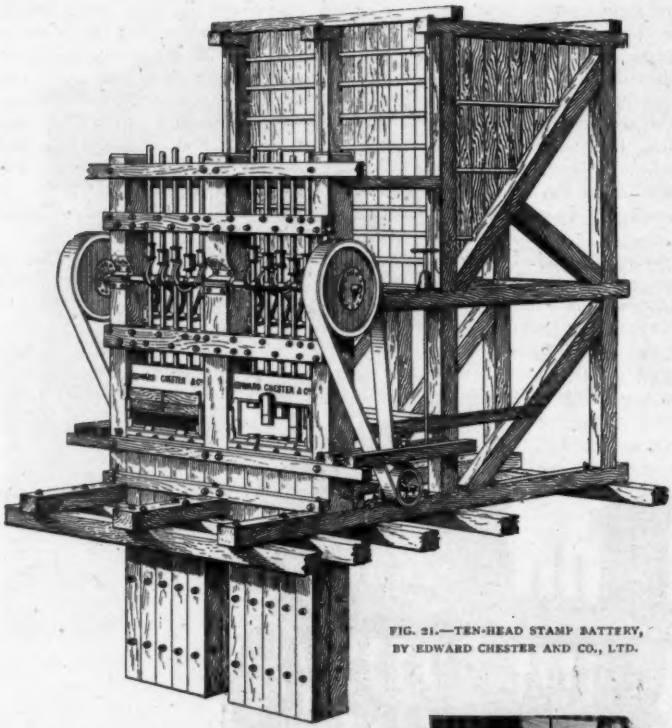


FIG. 21.—TEN-HEAD STAMP BATTERY, BY EDWARD CHESTER AND CO., LTD.

This battery is also very suitable for dry crushing.

MACHINERY FOR FINE CONCENTRATION.

There are numbers of these machines, made under different names, which more or less bring about the desired result. The degree of concentration, of course, depends principally upon the manner in which the product is afterwards to be treated.

The vanner was the result of a long series of experiments in the concentration of silver ores, carried out from 1872 to 1874 by the late Mr. W. B. Frue, assisted by Mr. Walter McDermott, who has ever been identified with the introduction of the machine. The special object of the experiments was the treatment of low-grade silver ores of the Silver Islet Mine, on Lake Superior, and Mr. Frue's long experience in the dressing of copper in the Lake Superior region determined him to attempt concentration.

Many forms of jigs, shaking tables, and belts with various motions were tried, and in the end a side-shaking travelling belt was evolved, which, even in the experimental stage, gave exceptional results.

These vanners turned out so satisfactory that a 50-stamp mill with 24 vanners was

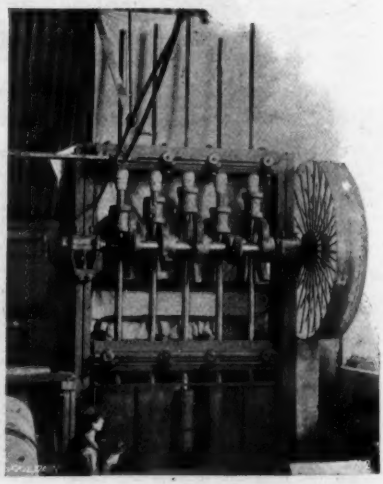


FIG. 22.—THE "JELMAN-WEPF" STAMP BATTERY.

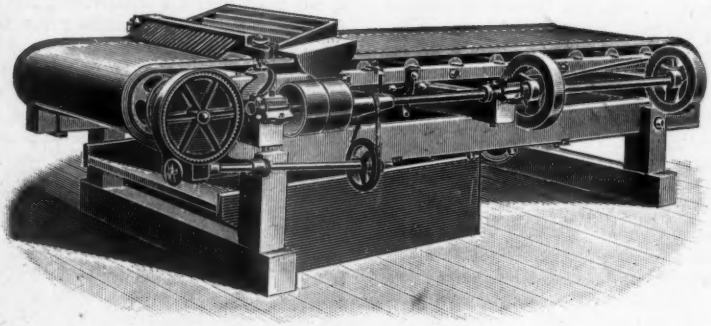


FIG. 23.—STANDARD FRUE VANNER.

afterwards built at the Silver Islet Mines; it paid for its cost of erection in about four months' run, and was used at intervals for a period of seven years whenever ore of low-grade had accumulated.

The Frue Vanner,

as manufactured by Messrs. Fraser & Chalmers, is illustrated in Fig. 23. It consists of an endless rubber belt, supported by rollers so as to form a plane inclined rubber surface 4 ft. wide, 12 ft. long, and bounded on the sides by rubber flanges. The belt travels up the incline and round a lower drum, which dips into a water-tank in which the mineral is collected. In addition to the travel of the belt, the latter receives a steady shaking or settling motion from a crank-shaft along one side, the shake being at right angles to inclination and travel of belt. The ore is fed upon the belt in a stream of water about 3 ft. from the head, and flows slowly down the incline subjected to the steady shaking motion, which deposits the mineral on the belt. At the head of the belt is a row of water-jets.

The slow travel of the belt brings up the deposited mineral, and the water-jets wash back the lighter sand, letting only the

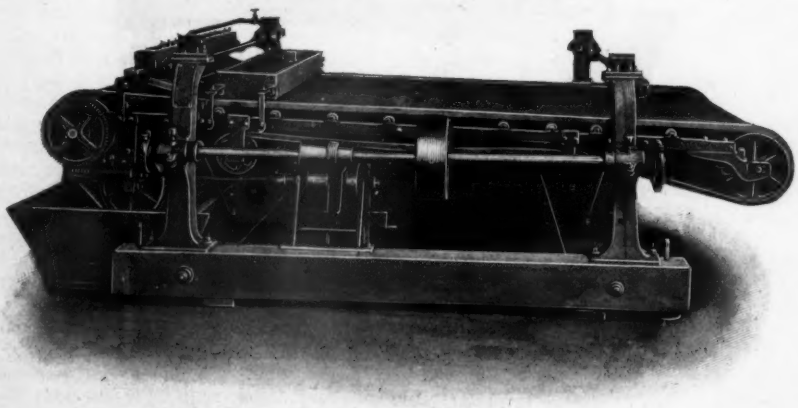


FIG. 24.—THE "JOHNSTON" CONCENTRATOR.

heavy mineral pass and become deposited in the water-tank below.

The inclination of the belt can be varied from ¼ in. to ½ in. per foot. Increasing the grade of the belt makes the bed of the pulp on the table thinner, and also has a tendency to make the concentrates cleaner.

Increase of travel of belt increases the thickness of the bed of pulp on the belt, and may tend to carry over a little sand with the concentrates.

Increase of speed thins the bed of pulp very rapidly, and also cleans the concentrates; also in very coarse crushing it shakes off the heavy sand.

At a normal rate of travel the belt will carry over as much as 1,000 lbs. of clean concentrates in 24 hours.

For one machine from one to one-and-a-half gallons of clear water is used at the head, and from one and a half to three gallons per minute with the pulp. The boiler for a 5-stamp mill with two concentrators requires one gallon per minute, hence, in places where water is extremely scarce, two gallons a minute can supply five stamps, two Frue ore concentrators and the boilers, by settling and pumping back.

Roughened belts have been tried, but it has been found a disadvantage as compared with a smooth surface for saving fine slime mineral. It has been demonstrated, however, that a certain form of belt surface has an important effect, allowing the use of steeper grade and some water, and, as a consequence, greatly increasing the capacity.

Messrs. Robey & Co. use a belt, for their vanner mode of canvas, with rubber insertion.

"Johnston" Concentrator.

In this vanner the horizontal side-shake is done away with; in its stead a suspended shaking frame with four non parallel suspension links have been adopted, the upper end of the links being, when attached to the stationary frame, about 3½ ins. further apart than the lower ends when attached to the shaking frame. The non-parallel position of the links causes the shaking table to receive a slightly undulating motion very similar to that of a batea or miner's pan, and gives a top-wash to the sand, while the sulphurets on the bed remain undisturbed.

The supply of pulp, after passing through a staggering device, is received upon the metal bottom of the pulp-box.

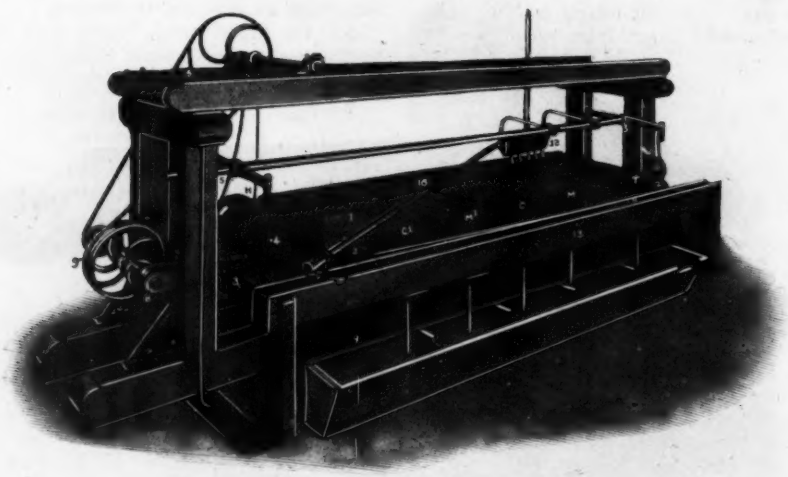


FIG. 25.—THE "LÜHRIG" VANNER.

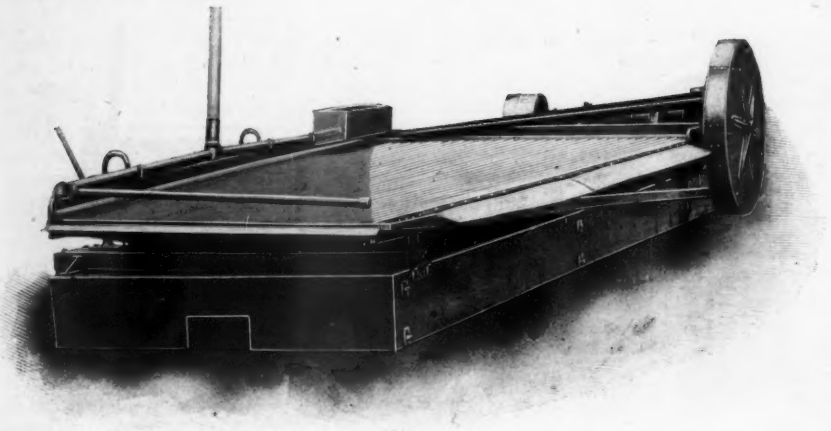


FIG. 26.—THE "WILFLEY" ORE CONCENTRATOR: FRONT VIEW, SHOWING THE TABLE.

This metal bottom is provided with slots which are parallel to the edges of the endless belt, and which are $\frac{1}{4}$ in. wide, 12 ins. long, and 10 ins. apart, and hence cause the pulp to fall upon the belt. In falling upon the belt, the pulp is distributed over the 10-in. spaces, and separation of sulphurets and sand immediately takes place, the sulphurets passing to the clear water at the head of the table without being again disturbed by the entering pulp, and the sands are washed to the lower end of the table and discharged.

The sulphurets, while being carried to the head of the shaking table, pass under the clear water-box, which is solidly supported on the posts. The water from the clear water-box flows first on to a distributor, which is attached to the shaking table and moves with it, and from the distributor the water is delivered through a series of small tubes, placed about 5 ins. apart, on to the endless belt in such a manner that the sulphurets are very little disturbed.

The endless belt, carrying the sulphurets, now passes over the roll at the head of the machine and under a roll whose surface is about $\frac{1}{8}$ in. below the surface of the water in the sulphuret-box, where most of the sulphurets will be discharged from the belt. To complete the removal of the sulphurets from the belt, a spray of water is applied thereto from a perforated pipe attached to the posts at the head of the table. There is also a second spray pipe inside of the loop of the belt, so that the inside surface of the belt may be washed when desired.

The proper grade for the butt is from $\frac{1}{4}$ in. to $\frac{5}{16}$ in. to the foot. This is about the range, and depends on the character of the material being worked.

The belt used for this concentrator is made of india rubber $\frac{3}{16}$ in. thick, with a bead on each side $\frac{7}{8}$ in. deep, and $\frac{3}{4}$ in. wide at the bottom, and at the top half-round, with a radius of $\frac{11}{32}$ in.

For a 5-stamp mill $\frac{1}{2}$ to 1 miner's inch of water is required, which equals 5·4 to 10·8 gals. per minute. If water is scarce, that leaving the concentrator can be settled, and more than half of it returned and used.

A 6-ft. moulded edge rubber belt machine is sufficient to handle the pulp from five stamps crushing from 12 tons per day of 24 hours. A 4 ft. 6 in. machine will handle 8 tons per 24 hours. This machine is manufactured in the Risdon Iron Works, San Francisco, and illustrated in Fig. 24.

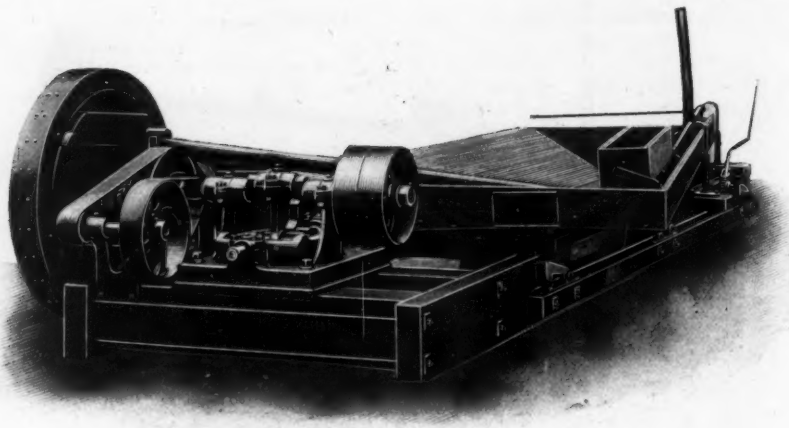


FIG. 27.—THE "WILFLEY" ORE CONCENTRATOR: BACK VIEW, SHOWING THE DRIVING GEAR.

THE EMBREY VANNER.

This machine was patented by Mr. J. J. Embrey in the year 1881. It is practically identical with the old form of the well-known Frue Vanner, the essential difference being in the belt employed, and in that the shaking motion of the Frue Vanner is at right angles to the travel of the belt or apron, while in the Embrey Concentrator the shaking motion is in the same direction as the belt-travel.

The material which this concentrator is adapted to treating is such as will pass a screen of 30 or 40 holes to the lineal inch, although even coarser sizes have been successfully concentrated. No sizing or classification is required, because the finest mineral particles cling with the greatest tenacity to the belt, and the layer of particles of lighter rock is easily kept moving by means of the shaking motion and descending current of water.

For gold mills, or where quicksilver is employed before concentration, the ordinary pulp distributor is modified in form so as to constitute an amalgam and quicksilver saver. This is accomplished by lengthening the distributor, covering the same with an electro-silver plated coper, and attaching cleats top and bottom, which form two shaking riffles; and the whole makes the most effective amalgam and quicksilver saver which can be used, embodying as it does, by its motion and construction, the principle of the gold pan, the riffle, and the copper-plate amalgamation.

The capacity of these machines depends, of course, on the fineness of material treated and its character. Very finely crushed ore carrying rich mineral, which must be closely saved, has to be worked slowly. The quantity of ore, crushed to a 40-mesh, which the machine will concentrate is from 6 to 15 tons per 24 hours. The speed of the crank-shaft is from 200 to 235 revolutions per minute, according to ore and inclination of the belt, which varies from $\frac{1}{4}$ to $\frac{1}{8}$ on the foot. To drive each machine requires less than $\frac{1}{2}$ h.p. Messrs. Fraser & Chalmers are the sole makers of this concentrator.

THE "LÜHRIG" VANNER.

Referring to Fig. 25, it will be seen that the machine is a side-delivery vanner, its main feature being an endless I. R. belt, supported by small rollers underneath the belt and running over two large end rollers. The rollers are fixed on a frame, which is suspended by means of S

hooks to two supports. These supports can be raised or lowered by means of a screw handle, thus allowing the whole frame to be tilted as desired. The frame carrying the belt is set level in the longitudinal direction, and at an inclination transversely sloping down towards the front.

The cam on the driving-shaft revolves 75 to 100 times per minute, thus imparting 150 to 200 strokes to the belt frame, which is pushed back into position by a strong spring at the other end.

One of the end rollers is driven by a chain-gearing, thus causing the belt to travel slowly from right to left. The ore pulp is fed through a feeder on the right-hand top corner of the belt. The feeder is provided with hollow hair brushes, which slide on the belt. The pulp passing through the brushes is thus delivered very closely on the belt. Any air bubbles, which so frequently cause the float metal to be carried off with the slime water, are broken up by the brushes, and the flow of the water down the belt is also checked to a certain extent.

In front of the vanner is the receiving launder, into which the various products flowing down the inclined belt are discharged, and thence delivered into separate receptacles through the down pipes.

A spray pipe, having small holes through which the necessary clear washing water is supplied on to the belt, is fixed diagonally across the belt.

This vanner requires about $\frac{1}{8}$ h.p. to drive it. The speed of travel of belt is about 8 to 10 ft. per minute, and can be easily regulated to suit the ore pulp, coarser sand requiring a somewhat greater speed than fine slimes. The various products are cut off by movable slides, which can lead into their compartments any parts cut from the separated minerals as they are delivered over the plate in front of the vanner belt. The middlings can either be returned automatically for re-treatment on the same vanner, or, in large plants, are collected together with the riddlings from other vanners and automatically re-treated on a separate vanner for riddlings.

The capacity of the vanner varies according to the nature and fineness of the pulp and its richness in sulphurets. The best practice, working under ordinary conditions, is to put two vanners to five stamps, if the pulp is crushed to pass, say, a 40-mesh screen, with heavy stamps and material rich in mineral.

This vanner is supplied by the Lührig Coal and Ore Dressing Appliances, Ltd., Westminster, London.

The "Wilfley" Ore Concentrator.

Fig. 26 is a front view, showing the table, and Fig. 27 a back view, showing the driving gear. The table consists of a flat surface 7 ft. wide by 16 ft. long, upon which are a series of riffles of varying length.

The pulp is fed upon the table near the movement end, and flows down the adjustable inclined surface across the series of riffles towards the tailings discharge. The movement is so constructed that the table has a quick motion at the outer end of its stroke and a much slower motion at the inner end. This movement causes the ore particles to settle into layers, leaving the clear silica at the top exposed to the action of a stream of wash-water, and at the same time causes the entire mass to move up the slight incline of the table towards the concentration box. The pulp is fed upon the table through a series of small holes in the side of the pulp-box, and during the entire time it is upon the table is kept constantly under a sheet of waste-water, which prevents any loss through the mineral floating off on the surface of the water, which is a frequent source of loss in many tables.

As the pulp moves up the table the upper layer of sand is carried over the riffles by the water, while the concentrate is being steadily settled and a fresh layer of sand is brought to the surface. The concentrates, after being freed from a greater part of the sands, move beyond the riffles upon the plane portion of the table, where it is washed by a stream of clear water, which carries the final particles of silica into the tailings discharge, and also carries the minerals down the table in the order of their specific gravity. Galena is moved but little by the wash-water, but

by the motion of the table is driven towards the concentration box. Iron pyrites are carried further down the table than galena; zinc blends, quartz with mineral attached, and clear sand are carried down in the order named. The lines between the various streaks of mineral formed by the combined action of the wash and motion of the table are so distinct that it is an easy matter to so adjust the table and wash-water that the clear sands are run into the wash-spent, and the quartz with the mineral attached into the middlings-spent, to be automatically returned to the table by the raff-wheel and re-treated, while all the concentrates are delivered into the concentration box.

The shaking motion is produced by a set of toggles and brought back by means of a spring, the toggles obtaining their movement by an eccentric on the driving-shaft, which is provided with fast and loose driving pulleys. The raising and transversing of the table is performed by means of a ratchet lever and wedges, which is shown in the back view Fig. 27. The table is covered with linoleum.

This concentrator is manufactured in Great Britain by Messrs. Bowes, Scott & Western, Ltd.

The table should run about 240 revolutions per minute, and should have a stroke from $\frac{5}{8}$ to $\frac{3}{4}$ in., but in no case to exceed 1 in. nor less than $\frac{1}{2}$ in.

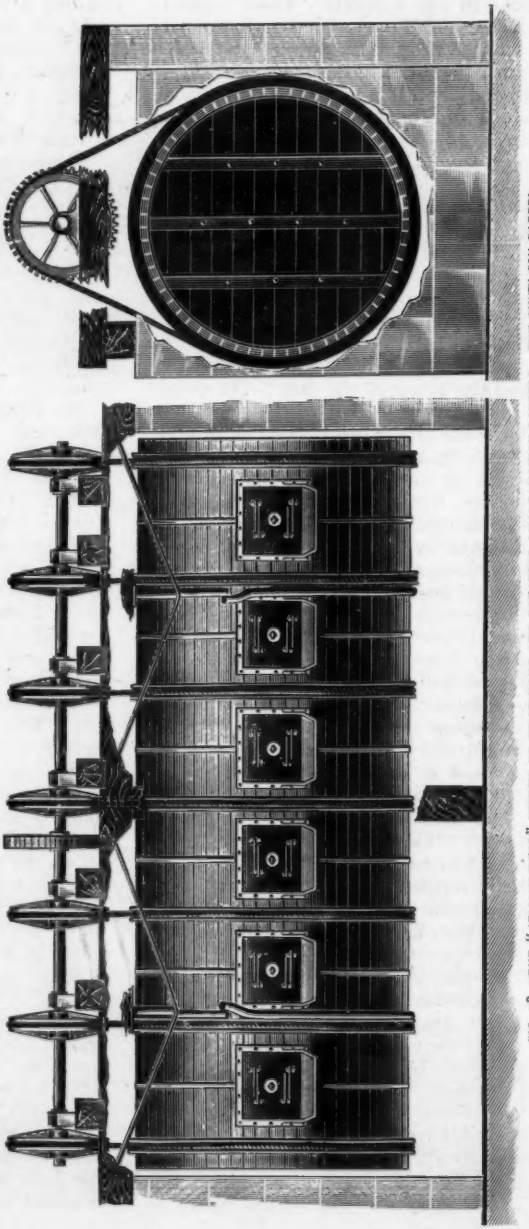


FIG. 28.—THE "JELMAN-WEPF" SYSTEM OF SUSPENDING AND ROTATING AMALGAMATION BARRELS. THE SIXTY-TON BARREL.

The "Jelman-Wepp" Rapid Cyanide Process.

Cyanide is one of the chemicals frequently used in the arts for keeping gold in solution; and at the present time cyanide of potassium is largely used for the tailings —that is, crushed ore that has already passed over the amalgamating and blanket tables. The tailings are placed in vats, and subjected to the action of solutions of cyanide of potassium of varying strengths, down to 0·2 per cent.

The chemical reaction of cyanide of potassium with gold is as follows, according to Elsner :—

$$2Au + 4KCy + O + H_2O = 2KAuCy_2 + 2KHO$$

—that is, a double cyanide of gold and potassium is formed.

The ore is crushed to a certain fineness, depending on the character of the gangue. It is then placed in leaching vats, with false bottoms for filtration, similar to other leaching plants. A solution of potassium and other chemicals of known percentage is run over the pulp, and left to stand a certain number of hours, depending on the amount of metal to be extracted. It is then drained off, and another charge of the solution is used, but of less strength, which is also drained. The pulp is now washed with clean water, which leaches all the gold and silver out, and leaves the tailings ready for discharge, either in cars or sluiced away by water, if it is plentiful.

The Jelman-Wepp rapid cyanide process consists of huge wooden barrels (Fig. 28), which can, of course, be made of any length and diameter suitable for the plant required. The barrels are provided with steel channel hoops, in which are placed fine flexible steel wire ropes or chains on which the barrels are slung. These wire ropes or chains pass in turn over grooved pulleys, which, when the shaft is rotated, cause the barrel to revolve. In this way the contents of the barrel are kept churned up during the whole of the time that they are under treatment.

As is the case with the vats, the barrels are charged with fine-crushed ore. The water is then run in, and the required quantity of cyanide of potassium added. The barrel is then set in motion by the rotary action of the steel slings in which it is suspended, these being set in motion by rope-driving gear attached to a small engine. By these means the potassium, as it dissolves, is necessarily brought into contact with every particle of gold in the crushed ore. It will be noticed that the ore, falling by specific gravity through the solution as the barrel revolves, thus breaks up the slime, as it is thoroughly mixed with its own sand; and by the constant movement of the sand and all other contents of the barrel, the chloride of gold, formed by the action of the cyanide, is constantly removed from the gold, thus leaving a fresh surface for the cyanide to act upon. An arrangement is made by means of a bent pipe on the barrel that fresh air is admitted, and foul gases allowed to escape, during the working.

When the barrel has been revolving a suitable time it is tilted, in order to draw off the gold solution, and when this has been done the barrel is filled up again with water to wash out the cyanide and any chloride of gold that may remain in the crushed quartz. After the barrel has been tilted the second time, the water is drawn off by means of a suitable filter on one side of the barrel. The barrel is then turned with the door down, the tailings are dumped out very quickly, and all is ready for re-starting.

(*To be continued.*)

Philip R. Björling

Note.—It was originally intended to include the whole of Mr. Björling's article, which is in reality a comprehensive survey of the plant at present used in gold-mining operations, in the present number, but owing to the lengthy nature of the contribution it was found more expedient to continue it through two or three successive issues. In doing so, it was found necessary to somewhat alter the author's original classification.—The Editor.

The Past, Present and Future of Electricity in Mining.

By SYDNEY F. WALKER, M.I.Mech.E., M.I.E.E., A.M.Inst.C.E.

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THE PAST.

THE use of electricity in mining operations is of comparatively recent growth. Its earliest use was probably for the purpose of firing the charges that are employed in blasting, and the apparatus then employed would be the frictional machine that used to be the *pièce de resistance* on the lecture table thirty years ago.

It would also be about thirty odd years ago that the first electric signals were introduced into mining.

In each case the introducers were enthusiastic amateurs, and the apparatus at their disposal must have given them many an anxious time. It was only on the advent of the telephone in 1878—though that apparatus was not then in a practical form—that mining men began to have a little faith in the possibility of electricity being of service in mining work.

The appliances available even at that time were expensive and unreliable, and it was only after many years of very hard work, and the expenditure of a good deal of money, that they became at all marketable.

There was also very little knowledge of electricity at the time, outside of the Post Office, and the submarine cable companies, and railway companies' telegraph staffs.

The text-books of the time teemed with errors, some of which are to be found in them still. The electric light had had a fitful existence, mainly of the advertisement company-promoting type, and was practically dead. The pioneer in electrical work of any kind had to dig out his own way at, usually, a painfully slow and costly rate.

The advent of the telephone, followed by the Paris Exhibition of 1878, in which the Jablochoff Electric Light was exhibited, illuminating the Avenue de l'Opera, altered matters a good deal. One of the apparatus that was exhibited in Paris was brought over to London, and served as an advertisement for Mr. John Hollingshead outside the Gaiety Theatre, and the same apparatus was tried at the Cymmer Colliery in the Rhondda Valley, shortly after, but without success. Shortly after, again, Mr. Brush taught us on this side how to run several arc lights in series, we having up to that time been using one machine for each lamp, and sometimes two, as it was found difficult in those days to maintain a sufficiently constant E.M.F. for the regular working of the lamp. The Brush system was introduced, with fair success, at a few collieries; but the lamp which did the most, in those days, to make the electric light possible in collieries, was the early form of Brockie Arc Lamp. This lamp, which we should not tolerate anywhere now, was then a model of steadiness and simplicity. It did not go out as long as things were fairly well looked after. It worked by allowing the upper carbon rod of the arc to fall upon the lower one every 15 to 45 seconds and instantly picking it up again. Each feed caused a wink, which was painfully visible indoors, but which for outdoor work, such as colliery yards and similar places, gave, for that time, very good results.

Following closely on this came the invention of the Incandescent Lamp, which was at once adopted by a few collieries, the machines used being series and shunt-wound.

The working out of the compound machine gave another impetus to colliery lighting by electricity, which has since

steadily invaded the whole of the field of mine lighting.

Fontaine's announcement that the Gramme machine was reversible bore fruit some years after, in the establishment of the first pumping plants at collieries, a development that has become now very general, the early installations consisting of two small series machines, one being driven as a generator, the other being driven by the current from the first, and driving the pump.

Quite early, also, Messrs. Siemens and Halske, of Berlin, fixed an installation consisting of an electric locomotive, in the Zankeroda colliery in Prussia, which the writer believes is still running, and in which the loco takes its current from an iron rail fixed at a convenient height by the side of the roadway in the mine.

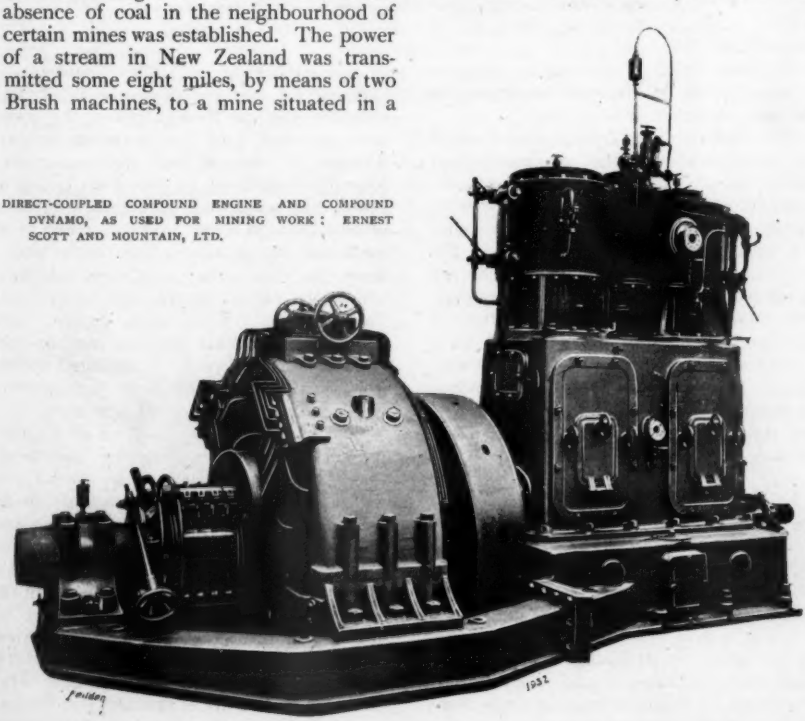
Very early, also, the utility of electricity for overcoming the difficulties due to the absence of coal in the neighbourhood of certain mines was established. The power of a stream in New Zealand was transmitted some eight miles, by means of two Brush machines, to a mine situated in a position where no coal was near, and where the cost of carriage of coal would have seriously handicapped the economical working of the mine.

From all these beginnings have been developed the large quantity of electrical apparatus now in use in mines all over the world, a quantity, however, which probably represents only a small fraction of that which the near future will see in use.

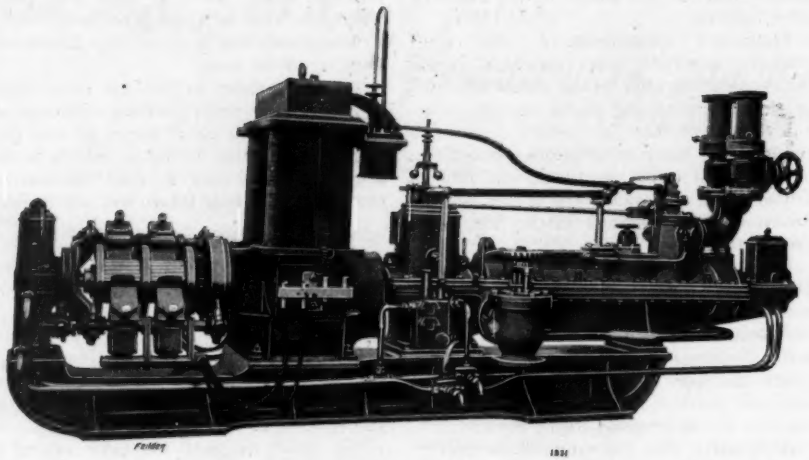
THE PRESENT.

At present electricity is used in every operation of mining, both coal and metalliferous.

Beginning with shot-firing, there are few mines now in which blasting is necessary in which the shots are fired in any manner except by means of electric currents, and the apparatus consists of either small magneto machines arranged to furnish the necessary current and



DIRECT-COUPLED COMPOUND ENGINE AND COMPOUND DYNAMO, AS USED FOR MINING WORK; ERNEST SCOTT AND MOUNTAIN, LTD.



A PARSONS' TURBO-ELECTRIC GENERATOR, AS USED AT ACKTON HALL COLLIERY.

pressure for from two to eight shots, or a small battery of dry cells arranged for the same duty.

The shots are fired by detonators which are furnished with the necessary heat either by a spark passing between the ends of two copper wires, or by a current passing through a small platinum wire, the current passing in any case in the midst of a powder of fulminate of mercury or other similar substance; and the shot-firer takes the magneto or the battery in its case, slung over his shoulder, to a convenient point out of harm's way, makes the connection to the wires leading to the fuses, and when all is ready, fires the shot by a turn of the handle, or by pressing a key, the whole of the shots being fired simultaneously. The great advantage in firing shots by electricity is, the shot-firer can return to his shots immediately after they have fired, in place of having to wait a certain time, as with other methods, to see if any have missed fire.

Signalling is now practically universal by electricity, on all haulage roads, inclines, and similar situations, and it is used in a few cases for shafts, though in not as many as it might be, with advantage.

The signalling apparatus consists of very strong and powerful electric bells, sometimes single stroke, striking the gong once for each time that a current is sent through the coils of their electromagnets, sometimes vibrating or trembler, giving a sound like an alarum each time a current is sent through them. The connection is made on engine roads, and similar situations, by pressing two iron wires together, which are run along the side or roof for the purpose. With shaft signals, and some of the signals that are used on the surface, strong levers are arranged inside iron boxes which complete the electric circuit, each time the lever is worked.

The current for the signals of all descriptions is furnished by batteries, usually of the Leclanché type, either the open type, or the so called dry cells, or in some cases, what is known as the mercury-bichromate cell is employed. In a few cases, the current for the signals is supplied by accumulators charged from the lighting service, and in a very small number of collieries from the electric lighting service itself. At Ackton Hall colliery a very pretty arrangement is in operation. The current is taken, under ordinary conditions, from the lighting service, but in the event

of anything happening to this, an accumulator is automatically switched in, till the matter is put right, and an incandescent gives warning when anything goes wrong, another lamp slightly heating each time a signal is made.

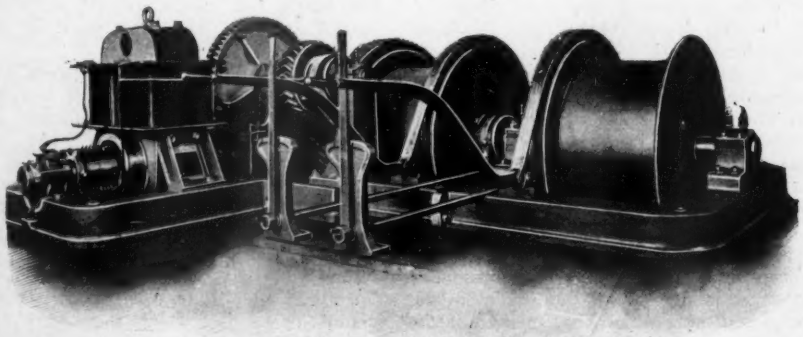
The telegraph has been used for a great number of years, between the shipping office and the colliery, and between different collieries under the same management, and this has been supplemented by telephones, since the expiration of the patents, sometimes used on the same wires as the telegraph, and at others on separate wires. The great objection to using the same wires for the two services is—the powerful currents used by the single-needle instruments which are always passing in the other wires on the same poles, and even those passing in wires on other poles at a little distance, give rise to a terrible clattering in the telephone receiver, which renders it difficult to hear. For communicating between managers, in the quiet time after business hours, however, they are of great service, and as the telephone displaces the telegraph more and more, the matter will right itself, though there is another and more serious difficulty in connection with the use of wires running on the same poles, or even in the same neighbourhood, viz., the ability to hear each other's messages. Where the wires are used by firms in different trades, this does not usually matter, but where all are in the same trade, it becomes serious.

The difficulty will be overcome, eventually, in the way that the same difficulty has been overcome in telephone exchanges, by doubling the wires and giving each wire a twist round its other half.

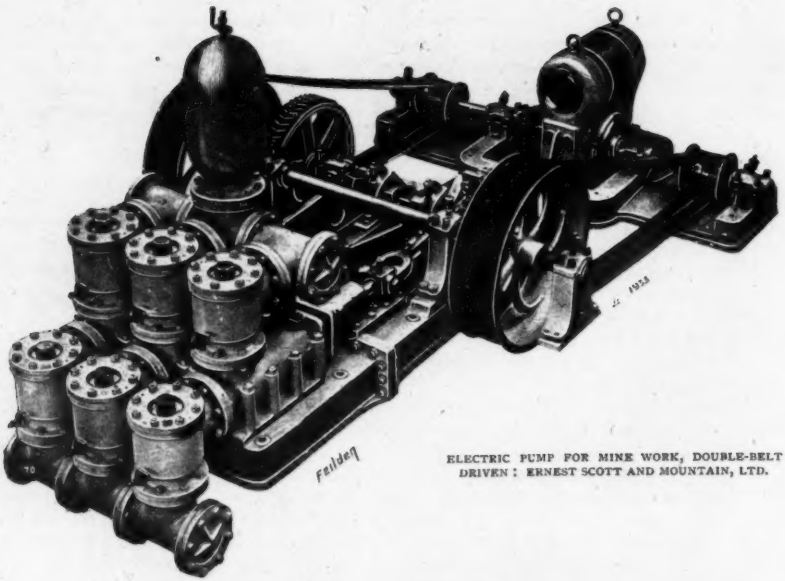
For communicating about the colliery and between different collieries under the same management, the telephone is very largely used, the managing director, or mining engineer in charge, having usually a small telephone exchange at his office, by means of which he can communicate to every part of each colliery under his charge.

For communicating between the surface and underground, and to the workings, ordinary telephone apparatus is employed from top to bottom of the shaft; but for communicating with the main roads, and as far into the workings as possible, the parallel iron wires of the engine plane signals are made use of, a pair of watch telephones being carried in the pocket by overmen, riders, etc., and communication being made by merely connecting the telephones across the iron wires, after having called the engineman's attention by a pre-arranged signal. The engineman has a switch in the engine house which enables him, on receiving the speaking signal, to connect the apparatus in the engine house, placed for the purpose, in circuit with the signal wires.

Lighting is almost universal by means of electric light for the surface, the sidings workshops, engine houses, etc., of all



ELECTRIC CHAIN AND TAIL HAULAGE: ERNEST SCOTT AND MOUNTAIN, LTD.



ELECTRIC PUMP FOR MINE WORK, DOUBLE-BELT DRIVEN: ERNEST SCOTT AND MOUNTAIN, LTD.

mines, and for the neighbourhood of the shaft bottoms, and a certain portion of the main roadways near the shaft bottoms in a great many mines. The engine houses underground are also usually lighted by electric lights, and, in many cases, the pumping stations and coal-cutting machines, the current in these cases being taken from the power service. In many cases also, the miners' village is supplied from the generating plant at the mine.

Portable electric lamps have also been introduced in a few mines in the county of Durham, and in a large number of mines in Belgium and France.

The lamps employed in mining work are, about the surface for the yards, usually enclosed arc lamps; occasionally a few open arcs are met with, and incandescent of different sizes, from 16 c.p. up to 300 c.p. The large incandescent lamp would probably have been used entirely, to the exclusion of the arc lamp, but for the advent of the enclosed arc, which has many of the advantages of the incandescent lamp, such as not requiring to be trimmed more frequently than after from 100 to 150 hours' burning, which in some cases may mean a winter's work, and they furnish very much more light for the same expenditure of energy. Burning with a higher voltage also, they lend themselves more readily to distribution than the old form of arc lamp. If the incandescent lamp were to be improved in efficiency, say to one watt per candle, with a reasonably long life, at full or nearly full candle power, it would probably again take the place of the enclosed arc lamp.

For underground, the incandescent lamp is used entirely, of from 8 c.p. to 100 c.p., the small lamps being sufficient for confined spaces, while the 100 c.p. lamps give very good illumination at high shaft bottoms and in similar positions. The portable miners' lamps in use give 1 c.p.

The electric light is rarely taken far from the shaft bottoms, the miners depending after that upon the portable lamps or candles which they carry with them. Any important point, however, such as a junction, is usually lighted by

incandescent lamps, even if it is some distance from the shaft bottom.

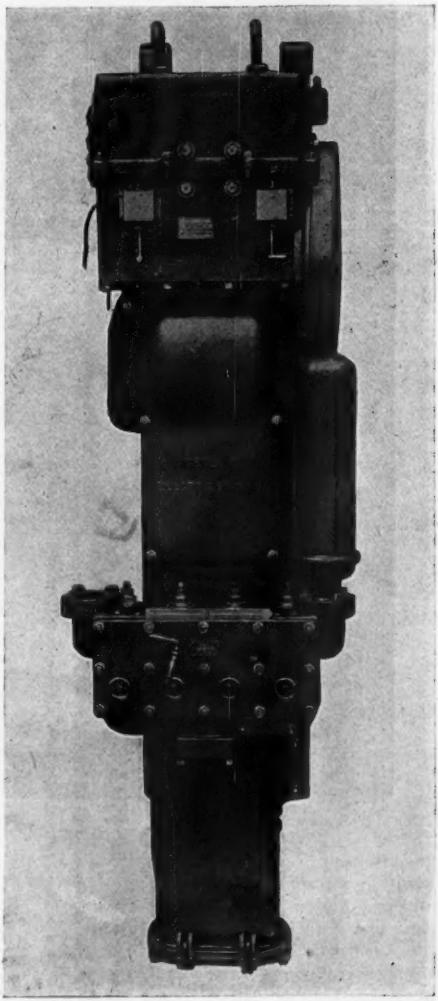
The underground lamps are sometimes protected by means of outer shades of glass, and by wire netting, such as may be seen around the gas lights in a theatre, but more often they are simply given an enamelled iron shade and no other protection, cheap lamps being employed for those positions in which they will be liable to breakage, the great objection to shades and wire guards being that they obscure the light, as coal dust always collects on and often inside them.

Pumping is done in a very large number of mines of all kinds by means of electric motors. For the drainage of dip workings they form a very convenient source of power, as the pump with the motor can be arranged on a truck, which will follow the water down as the workings move forward or the water recedes. Electric motors also form a very convenient means of delivering the necessary power to larger pumps for draining from lodgments, such as are arranged in many mines; and, again, they are exceedingly handy for driving pumps at a distance from the colliery, for water for the boilers and condensers, as is so often necessary.

For pumps for dip workings, the most convenient plan, and the one very generally adopted, is to mount the pump—usually a three-throw ram—on either a wooden or, preferably, an iron frame or bedplate, on which also the motor is placed, and a drum containing enough cable, double, to allow the motor to run a certain distance without making joints.

In some cases the motor is geared directly to the pump through spur or worm gearing, but more frequently it drives the gearing by means of one or two belts, or in some cases by ropes, the gearing transmitting the power on. This arrangement relieves the motor from the first heavy strains which are present on starting the pump.

The starting switch and resistance for this type of pump is sometimes carried on the same carriage. It is the best way, but occasionally it is set up on the side of the road in the neighbourhood of the pump, and moved on each time the pump is moved. This may save the starting switch and resistance from being under water, if, as occasionally happens, the motor and pump are drowned by a sudden inrush of water.



ELECTRIC SINKING-PUMP: BRITISH THOMSON-HOUSTON CO., LTD.

A "THOMSON-HOUSTON" ELECTRIC LOCOMOTIVE WORKING IN AN AMERICAN COAL MINE.

For the large pumping stations underground much better arrangements can be made, as the apparatus is not often moved, and in these cases it is usual to drive from the motor to a first motion shaft by means of ropes or belts, and from there by means of worm or spur gearing to the pump-shaft. A small pump-house is usually made in these cases, just as an engine-house would be, and a switch-board is fixed on the side wall, with the starting resistance, in any convenient position, and with a volt and ammeter and emergency switch, to show exactly what current is coming into the station, and to disconnect the supply service in case of accident.

The starting switch and resistance often form sources of trouble with underground

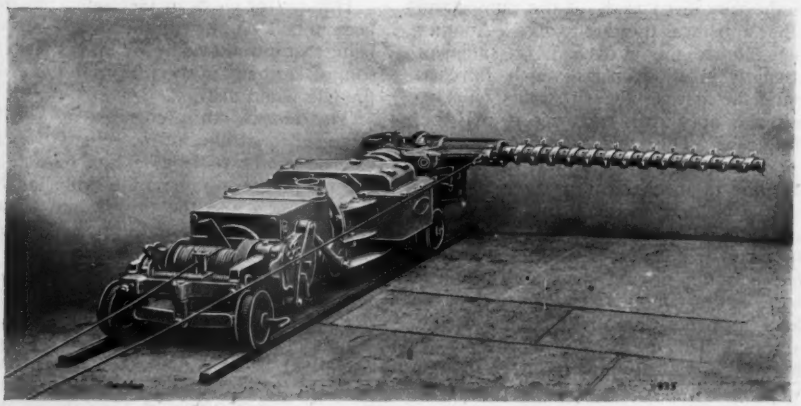
A "WESTINGHOUSE" ELECTRIC LOCOMOTIVE, AS USED IN SOME OF THE AMERICAN COAL MINES.

pumping plants, owing to the attendants not knowing that the resistance is not intended to be left in circuit, and heating taking place in consequence. Mining men have also occasionally used the starting resistances for the purpose of regulating the speed of the motor, a proceeding attended with disastrous results.

Electric haulage engines are now in use in a number of mines for the main haulage of the mine, and also for the secondary haulage, which feeds the main haulage.

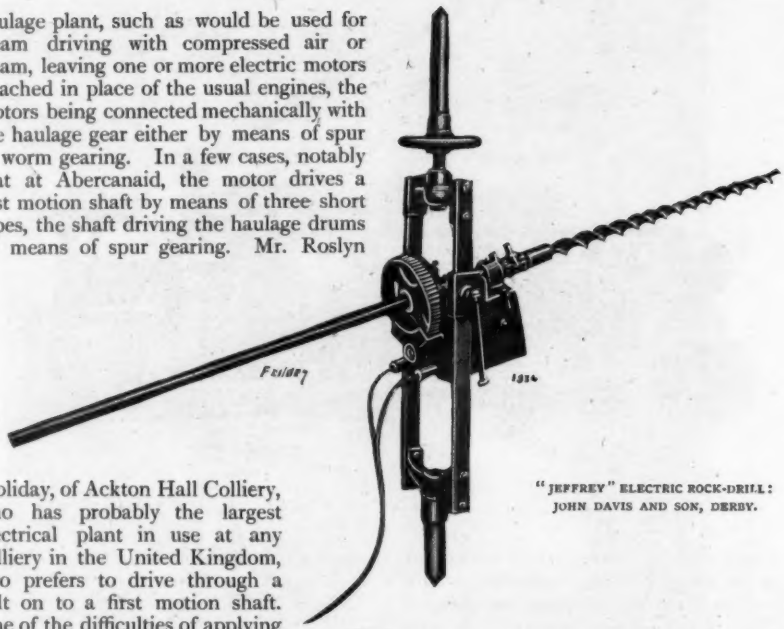
Electric motors have been applied to both main and tail haulage, and to simple inclines, from 10 h.p. up to 150 h.p., the latter being the largest that the writer is aware of at present.

The arrangement consists of an ordinary



ELECTRIC COAL-CUTTER: MAVOR AND COULSON, LTD., GLASGOW.

haulage plant, such as would be used for steam driving with compressed air or steam, leaving one or more electric motors attached in place of the usual engines, the motors being connected mechanically with the haulage gear either by means of spur or worm gearing. In a few cases, notably that at Abercanaid, the motor drives a first motion shaft by means of three short ropes, the shaft driving the haulage drums by means of spur gearing. Mr. Roslyn Holiday, of Ackton Hall Colliery, who has probably the largest electrical plant in use at any colliery in the United Kingdom, also prefers to drive through a belt on to a first motion shaft. One of the difficulties of applying electric motors to mechanical work such as is found in mines, is the matter of the reduction of the speed from that of the motor, which is usually going at a good many hundred revolutions per minute, anywhere from 300 to 1,500, down to the very low speeds of the pumps and other apparatus they are to drive. Another difficulty is the provision of sufficient strength in those parts which have to stand the first very heavy strains on starting the apparatus, whatever it may be, from rest. The interposition of a belt or ropes between the motor and the work in the line of mechanical transmission provides a yielding medium and relieves the armature of the motor in one of its weak spots, the point of mechanical connection between the driving shaft and the iron core, or the conductors. Reversal of the haulage plant when required is usually accomplished by mechanical means, the motors always running in one direction with usually a mechanical clutch for reversing.



"JEFFREY" ELECTRIC ROCK-DRILL: JOHN DAVIS AND SON, DERBY.

The electrical starting-gear for the haulage plant is the same as for the stationary electric pumps, and consists of a starting switch of the usual pattern, with starting resistance, together with measuring instruments and emergency switch.

Drilling for shots by electricity has not been much employed, the best example being that introduced by Mr. A. L. Steavenson, of Durham, in the ironstone mines of the Cleveland district.

The electric drill consists of a drill arranged for drilling rock, actuated by an electric motor of from 2 h.p. to 6 h.p., the motor gearing on to the drill-shaft by spur gearing, and the turning movement required in drilling and the feed being arranged by mechanical means.

The drill with its accessories stands on a tripod in the usual way.

Coal-cutting by electricity is now again coming to the front, after having been tried and failed some years ago, principally, in the writer's opinion, because too little power was provided in the motor which was used to drive the coal-cutter.

There was also another cause, viz., some of the early machines which were sent out were mechanically weak in some parts; and, in addition, the vibration of the machine in the act of cutting the coal would sometimes cause the connecting wires to work out of their terminals, with the result that an arc was formed sufficient to have fired gas instantaneously if any had been present.

These difficulties have now been fairly overcome by giving increased power in the motors and by better design of the whole apparatus.

In one form of electric coal-cutter that is now on the market there are two motors, one at each end of the frame carrying the machine, each gearing by means of bevelled wheels into a revolving wheel, which in turn gears on to a wheel on the disc which forms the coal-cutter. The cutters are carried on the periphery of the disc, which in revolving cuts into the coal. In other types of the disc coal-cutter only one motor is used. The motors may be of the continuous current, or polyphase type, but with the latter there is absolutely no spark to be seen anywhere, at starting or at any other time.

The starting switch and resistance is contained in an iron box, which is made gas-tight, the handle which works it being passed through a stuffing box. With the three-phase plant, no resistance is used, the motor being started with the cutter disc off the coal, and allowed to work its way in. In all forms of coal-cutter the machine as a whole is hauled forward by means of a haulage rope which is wound up on a drum on the front of the machine, the drum being turned by the motors at a speed determined by the attendant.

In the bar coal-cutter, which is also worked by electric motors, there is a steel bar standing out at right angles to the machine, with cutters on it, which revolves and cuts a certain depth under the coal, according to the length of the cutter bar.

The disc coal-cutter cuts under the coal to a depth of from 3 ft. 6 ins. to 7 ft., according to the conditions. The bar cutter cuts under a depth of from 3 ft. 6 ins. to 5 ft. 6 ins. The increased yield from the use of a coal-cutter was stated to the writer to be, at a colliery in Yorkshire, from 3·5 tons per man by hand to 6·2 tons per man by machine, besides the fact that a higher price was realised for the product.

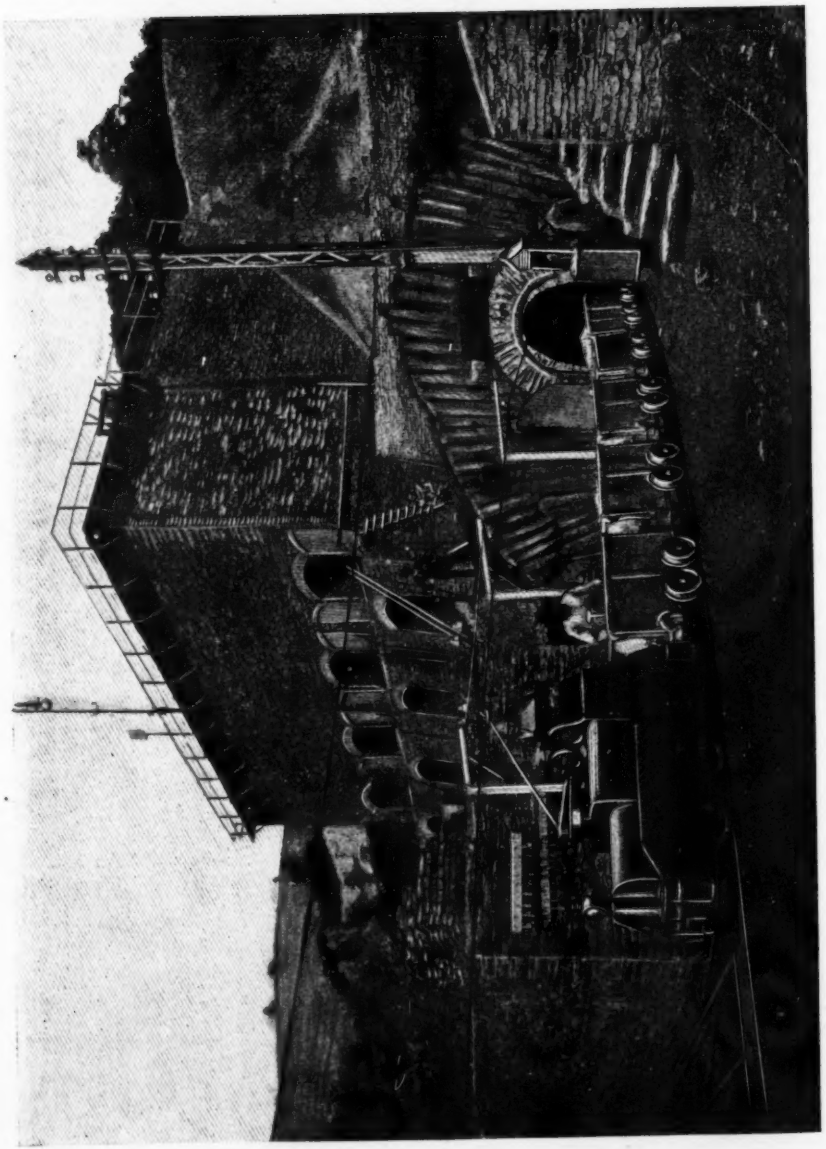
The makers of the bar coal-cutter claim that it requires less power to work it than the disc coal-cutter.

Electricity has been made use of to a far larger extent in America and the Colonies than in the United Kingdom, and more for gold and silver mines than for coal mines, and principally on account of the convenience of transmission of power from natural sources, such as that of falling water. In one case in Pennsylvania a number of coal mines, extending over an area having a radius of 4 miles, are worked entirely from one central electric generating station.

The Ruby mines of Burmah, and some of the gold mines of the Transvaal are also worked entirely, the stamps and electro-chemical plant included, from electric generating stations some miles distant, where water power is available.

In America also, and on the Continent, electric locomotives are very largely employed in mines of all kinds, taking their current from overhead trolley wires just as tramways do. These have not come into use in the United Kingdom, partly owing to the fact that so many mines in this country are worked by means of shafts, and partly because very few coal mines are perfectly free from gas at all times. It may be added that Her Majesty's Inspectors have discouraged the use of electric motors in coal mines, on account of the possible danger from the spark at the commutator of the motor.

The apparatus for light and power employed in mines, was up till very recently, all of the continuous current type, but the development of the polyphase motor, especially since the historic transmission from Llauffen to Frankfort, has led to the adoption of polyphase apparatus very largely on the Continent, in the Colonies, and in America. In this country there is at present only one mine, the Park Colliery at Garswood, in Lancashire, where polyphase apparatus is used for all



ELECTRIC LOCOMOTIVE WITH TRAIN OF MINE WAGONS, AS USED IN A GERMAN MINE

the electrical work of the mine. At other mines it is being taken up in a tentative manner, principally for coal-cutting.

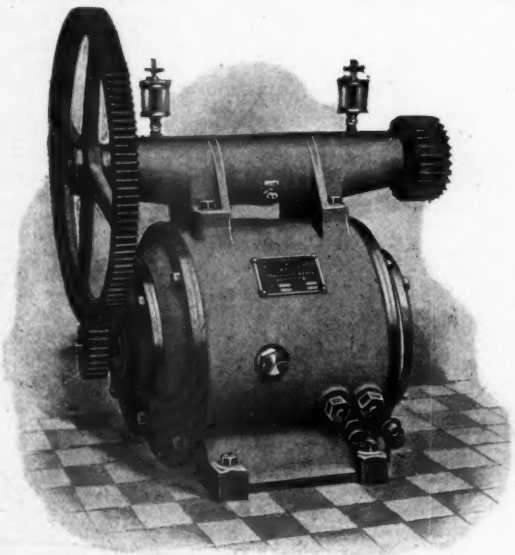
THE FUTURE.

The future should see a very large development of the use of electricity in mining of all kinds. At present, although every problem involved has been attacked and more or less successfully solved, and though every kind of work that was previously done by means of steam engines and by engines driven by compressed air, is now being done by electric motors in many instances, in nearly every case the electric plant forms only a very small fraction of the total power-distributing plant at the mine. The writer is not aware of electric motors of more than 150 h.p. being in use at any mine, though there is no reason why very much larger motors should not be employed.

In his opinion also, the whole of the work of every mine, or of every group of mines, including that now done by the winding engines, might with advantage be worked from one large electrical generating station, somewhat similar to the town electric generating stations. The waste of steam at all mines, and the cost of working generally, must be very largely in excess of what it need be if proper systems of electric distribution were introduced.

While in many mines water is present in such quantities that the cost of pumping is a very serious item in the total cost of working, in other mines there is considerable difficulty in providing water for the boilers, and condensing is out of the question. With a properly-arranged system of electrical distribution the generating station might be placed where the water is in abundance, and distributed at small cost to wherever it is wanted.

Bearing in mind the extremely low cost at which electricity is generated at some of the power stations in America, while



ENCLOSED ELECTRIC MOTOR, WITH GEARING:
ROSLING, APPLEBY AND FYNN, LIMITED, BRADFORD.

the charge for transmission can be made as low as one pleases by the use of high tension currents, without taking those high tensions into any position where they would be a source of danger, the cost of power for all the operations about a mine should be enormously reduced by this plan.

The development of the polyphase system of distribution has, in the writer's opinion, very greatly increased the resources at the disposal of the mining engineer in this direction, and he believes that the near future will see a very large development in this direction.

He understands that the owners of several of the large collieries in South Wales contemplate working their collieries by means of current supplied by the large power stations that are about to be put down. In his opinion the collieries in question, except in special cases, should be able to generate current at their own works at a much cheaper rate than it can be supplied at from outside.

There is a good deal to be said for the hesitation of mining engineers in their adoption of electricity for distribution in this country. The mining laws are very strict, and shareholders in mining companies are very anxious for dividends. Electrical apparatus has always been looked upon as very delicate, and the idea of taking large quantities of power from an electric motor seems, to some, like tempting Providence. Again, mining engineers have a great dread of the electric spark, and are not easily persuaded that it is harmless, especially when they see a large arc pulled out from the terminal of a machine in the manner described on a previous page. Still, these are incidents in the natural development of an agent that is little understood, and the fears of mining men will disappear, as they have disappeared in other cases, as the apparatus itself shows its reliability and freedom from dangerous developments. And as mining engineers also realise that the mechanical strains in a motor and in a generator are the same, and when they see generators converting thousands of horse-power day by day without a hitch, and realise that there is no reason why they should not convert the same quantities of energy from the electrical to the mechanical form, they will more and more adopt electricity, to their great convenience and to the great advantage of their shareholders.

Sydney F. Walker

The Westralian Goldfields.

(By OUR SPECIAL COMMISSIONER.)

INTRODUCTION.

SEARCH the world over, and you will find no greater monument of British enterprise and British grit than the gold-mining industry of Western Australia as it exists to-day. In approaching such a subject one feels impelled to devote a few lines to a recognition of the human effort and achievement which, in the face of difficulties all but insurmountable, has wrested from Nature her hidden wealth. It is, indeed, a marvellous story, this growth and progress of Westralian gold mining. In one decade a comparatively insignificant colony has sprung into the very first rank of gold-producing countries. Its population, its commerce, and its aggregate wealth have increased by leaps and bounds; and its future presents a vista of such magnificent possibilities that young Australia himself—the most invincibly sanguine of humans—finds the English language scarcely adequate to the situation.

It may be said that the beginning of gold mining in Western Australia was in 1887, when the discovery of the Kimberley field, in the far north of the colony, attracted a rush of miners. The output of gold in that year is recorded as 4,873 oz., worth £18,517 8*s*. Ten years afterwards, in 1897, the colony produced gold to the value of £2,564,976 12*s*. 9*d*. After Kimberley came the discoveries at Southern Cross, on the Yilgarn field, and subsequently Pilbarra, Nullagine, and Ashburton contributed to the rapid increase of the output, and practical mining men had the conviction borne in upon them that the future of the colony would be based upon gold. These discoveries naturally caused great excitement in the mining world of Australasia, and Westralia found herself the recipient of emigrants from all quarters, mostly impecunious, but all feverishly anxious and hoping for easily acquired wealth. For every one man whose expectations were fulfilled, hundreds found nothing but hardships and disappointment, and only too many an early and lonely grave. Great hopes had been indulged in of finding alluvial deposits on a large scale—a second Ballarat was anticipated—but nothing of the sort was found. The prospectors rushed from one new camp to another in their eager search for an easy El Dorado, and very quickly the public at home received the impression that Westralian gold-winning was of an essentially ephemeral character. Also, the inherent natural difficulties of the situation became painfully prominent. The cost of transport and the price of provisions and all commodities rose to fabulous heights. The harshness of the climate in the eastern wilds and the want of potable water played havoc with the miners. Fever became rampant, and the mortality from disease and exhaustion assumed a sensational character. The broken and disappointed men scuttled out of the country and gave the colony a bad name. Immigration and the influx of capital were checked, and the outlook for awhile was gloomy. But the stalwarts who remained had not long to wait for better times. The enormous distances were overcome by better organisation of transport. The camel was introduced from Asia, and proved an invaluable aid. Fresh finds of the most hopeful character were made, and eventually one fine morning Arthur Bayley came into Southern Cross with £2,000 worth of gold from a find 140 miles east of that place. His description of the discovery caused tremendous excitement, and the whole population went back with him and Warden Finnerty to the spot, which was at first known as Bayley's but is now Coolgardie. At first there was a mere wild, disorderly scramble. Twice in one night

Bayley's outcrop was rushed by the crowd and valuable specimens carried off. In consequence of the sudden influx of people into the wilderness, the prices of provisions were so high as to threaten starvation to the majority. Water fetched for a time *2s. 6d.* a gallon, and the most frightful hardships were suffered. The hot season saw Coolgardie almost abandoned. But the gold was there. Those who could stay profited exceedingly, and capital again flowed into the colony. Then followed a period of inflation. "Wild Cat" propositions were foisted upon a credulous public by the score, with the inevitable result that the speculating world, being, not twice, but several times bitten, became shy. A financial backwater threatened to paralyse the progress of the goldfields. But these fluctuations, this ebbing and flowing of the tide of public confidence is symptomatic of all goldfields—or, at any rate, of all those sufficiently prolific to capture the public imagination. After Coolgardie came Kalgoorlie and other important discoveries, and, slowly but surely, yielding to the irresistible logic of facts, capital regained confidence in Westralia, and the Colony can now proudly point to a record of output and dividends paid which must perforce silence the croakers and render the hypercritical harmless. Last year the total output of gold for the whole Colony reached the enormous quantity of 1,434,570·48 ozs., of the value of £5,451,367 16*s.* 6*d.*, while the first four months of this year yielded gold valued at £1,647,910 3*s.* 3*d.*

Having outlined the history of these goldfields so far as space will permit, it may be well to give a general idea of the geological characteristics, always bearing in mind that even now a large portion of the Colony is practically unexplored, and that some of the conclusions arrived at may be subject to modification in the light of future discoveries.

It may be said that the inland goldfields of Westralia are for the most part situated on a plateau, the longitudinal axis of which is probably the same as the general strike of the rocks contained in it. Taking a line north and south of Coolgardie, or one north-west and south-east, either might be deemed the approximate position of this main axis. Further acquaintance with the country and thorough exploration can alone determine the point. This inland plateau, crowned with diorite formations—using the term in the miners' sense—present an escarpment to the granite formations around them. The surface of the country generally presents a monotonous appearance, dreary and forbidding—vast sandy undulating plains, with a scant growth of scrub and gum trees, except where the land is so bereft of water that nothing will grow at all. The rocks are composed mainly of archæan peridotites, amphibolites, and their metamorphisms. These are surrounded by later intrusive archæan gneiss granite. The greater part of these fields consists of granite gneiss, which intersects the diorite formations and occasionally outcrops through them. The diorite takes the form of belts traversing the fields in a north-west and south-east direction. These belts, seldom more than a few miles in width, alternate with intrusive granite. But the productive area, it may be remarked, is usually confined to that portion of the diorite adjacent to the granite gneiss. Lateral disturbances, caused by the granite intrusion, seldom penetrate into the belt for more than a short distance, and a belt will sometimes run for miles without a break, the main reefs being parallel to each other and the strike of the belt. The cross reefs are seldom large, and usually take an east and west course, the dip being to the north or south. Rich pockets of gold are, at rare intervals, met with at the junction of these cross leaders and the main reefs. But as a rule neither the main nor cross reefs contain visible gold. Even crushing will usually not disclose it. It is not until chemistry is brought to bear that the presence of gold is detected.

The area over which these reefs extend is prodigious, but it is only in a small percentage of cases that gold can be won in anything like payable quantities. To an inexperienced prospector the Westralian fields are very disappointing. Great as the output of gold has been, the quantity

of payable rock actually proved bears a very small percentage of that which appears so hopeful, but which, even with the most up-to-date processes, is of no commercial value.

With one or two not very important exceptions, there are no alluvial deposits on the Westralian fields as yet discovered. A few miles north of Coolgardie there is a gully which, being for the greater part of the year the dry bed of a torrent, has been found to contain alluvial gold. The bed is about 6 ft. wide, and a few claims have been worked, though with unimportant results. In some other places where so-called alluvial gold is found there are leads which consist of broken quartz leaders, or possibly mullocky ones, broken up *in situ*, decomposition producing an appearance similar to that of alluvium. An important feature of the goldfields is the cement deposits. The well-known 25-mile cement is found in a decomposed intrusive granite. It occurs in patches. The felspars of the granite are completely kaolinised, the mica being hardly visible. The cementing material is the silica. These cement beds are never very thick, and although very rich patches sometimes occur, the result of mining them has, so far, not been encouraging.

With the exceptions mentioned, therefore, the goldfields consist of reefs, varying in character and still more in richness, but including a great quantity of stone yielding payable gold. Block formations comprise the greater portion of these reefs. Occasionally local disturbance has affected the rock to considerable depth, and large bodies of stone may be met with in comparatively deep sinking. In block formation types as in others, the absence of any true walls is a peculiar feature, the reef assuming an appearance of many leaders nipping in country rock, together with one or more larger leaders forming the main body of stone. Junction reefs, due to the junction of either granite or diorite formations with other diorite rocks, are numerous and form an important feature. Such reefs are permanent in depth, and often contain low-grade ore or occasional shutes of richer stone, the Southern Cross belt being a type of this formation. The normal and what may be regarded as the true type of formation consists of lodes formed from schists, slates and decomposed rock, impregnated with mineral matter. There is no defined wall, the whole of the country being considered as lode material.

There are now eighteen declared goldfields, viz. :—

	sq. mls.
Kimberley	46,886
Pilbarra	34,880
West Pilbarra	9,480
Ashburton	6,992
Gascoyne	5,061
Peak Hill	12,194
Murchison	20,513
East Murchison...	28,242
Yalgoo	18,921
Mount Margaret	42,154
Broad Arrow	590
North Coolgardie	30,609
North-East Coolgardie... ...	21,542
East Coolgardie...	632
Coolgardie	11,974
Yilgarn	15,593
Dundas	17,848
Donnybrook	—

Before proceeding to give descriptions of the more important or typical mines, I wish to acknowledge my indebtedness to the Agent-General for Western Australia, the Hon. Edward H. Wittenoom, and his staff, who have courteously placed all official statistics at my disposal, and also to Mr. Burton S. James for certain information concerning the geology of the fields as set forth in his book dealing with the subject.

HANNAN'S BROWN HILL.

An interesting and important mine is that of Hannan's Brown Hill at Kalgoorlie; and I may as well begin with this as with any other mine. Up to January last the managers, Messrs. Bewick, Moreing & Co., had studiously avoided any disclosure of information as to the work that had been done and the character of the stone, but at the date when the new dry crushing plant was taken over from the London and Hamburg Gold Recovery Company, the contractors, a full inspection of the mine and machinery was invited, and the policy of secrecy was discarded. The mine covers 26 acres, there being two blocks, one of 21 acres and one of 5 acres. The main shaft is a little over 400 ft. deep,

HANNAN'S BROWN HILL GOLD MINING CO., LTD.: GENERAL VIEW.

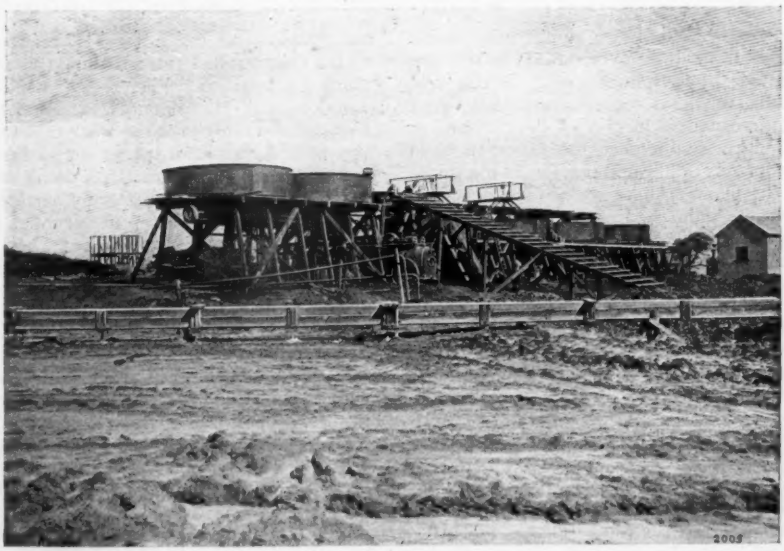
and five levels have been worked. No. 1 level is 64 ft. from the surface, the drive being 916 ft. in a northerly direction and 496 ft. south. Payable milling ore occurs for nearly its whole length, except for a short distance at the northern end. In a certain part of the north drive the stone is of extraordinary richness, and is used but sparingly for the purpose of equalising the quality of the crushings.

No. 2 level is 130 ft. deep, with a drive of 536 ft. south, and 307 ft. north. No. 3 level is 190 ft. from the surface, and has been driven 639 ft. south and 213 ft. north. No. 4 level at 270 ft. has a drive of 480 ft. south and 259 ft. north. Here the lode is altogether outside the oxidised country and within the pyritic zone. Seams of sulphide and calcite with quartz occur persistently, the sulphide seams carrying visible coarse gold. No. 5 level at 370 ft. is being worked in a southerly direction, but the value of the stone is low. The shaft is being deepened to 470 ft., when a sixth level will be put in. The underlay of the lode in the main shaft is only 80 ft. in 370 ft. So, at this rate, it is estimated it will not pass out of the property until a depth of 1,800 ft. has been attained. The character of the lode varies immensely, and its width is indefinable. The whole country may be considered a zone of fissile diabase, in which the mineral deposits occur in a series of overlapping lenticular masses.

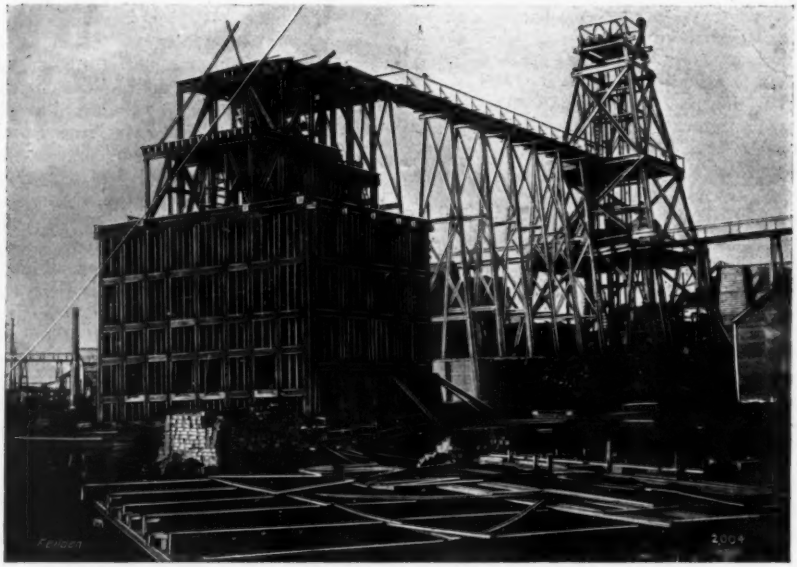
Very complete and excellent is the surface equipment. At the main shaft there is a double-cylinder engine with independent double drums, capable of working to a depth of 600 ft. The pumping plant is a single-geared engine and a Cornish pump by Davey, Paxman & Co. This plant has a lifting capacity of 200,000 gals. a day from a depth of 700 ft., which is nearly twenty times as much as will probably be required, as only about 8,000 gals. of water enters the mine daily. There is a straight-line air-compressor by Schram for the rock-drills, a small engine in the assay office, and one filter-press plant of the old mill. Steam is supplied by four steam boilers. Quite close to the shaft there

is an ore bin of 500 tons capacity. Thence the stone is carried along a tramway to the principal hoist, outside the "breakerisation." This latter is a building about 60 ft. high, and lofty enough to allow the ore, when once elevated, to gravitate through to the crushing appliances. The ore, hoisted to the top of this structure, is discharged from the trucks over the usual grizzly, and the coarser lumps then pass through Krupp crushers of the Blake-Marsden type. Then the stone encounters high-speed crushing rolls, which reduce it to a fineness suitable for drying purposes. It then travels through rotary drying furnaces 40 ft. in length, whose speed is variable according to the moisture of the stone. Next, the ore is passed through revolving screens, which separate from the mass the coarser part which requires further crushing. This is done by three Krupp ball mills. The stone, thus powdered, is elevated to a patent ore-sifting appliance, which separates it into three grades of fineness.

The first is an impalpable powder, which at once passes to the slimes plant. The other two grades are taken to the leaching vats and treated by the ordinary cyanide process. If gold of too coarse a grain to be dissolved by the cyanide solution is found in these sands, it is passed through two Wheeler pans and settlers and over amalgamation plates. The residue is conveyed to the waste heap. The dry slimes, after leaving the separator before mentioned, are passed through mixers, where the cyanide solution is added. The resultant pulp is then conducted through a series of agitating pans, during which the gold is dissolved by the solution. The pulp then goes through montejus, and from thence by air pressure is forced into the filter presses, where the solutions containing the gold are extracted. The cakes from the filter press are practically freed from gold and are conveyed to the waste heap. The solutions carrying gold from both the leaching vats and the filter press are next put through the precipitating house, where the ordinary zinc



THE GREAT BOULDER PERSEVERANCE MINE: TAILINGS PLANT



THE GREAT BOULDER PERSEVERANCE MINE: MAIN SHAFT AND BUILDINGS IN COURSE OF CONSTRUCTION.

process is used. The slimes, after being taken from the precipitating boxes, are treated by sulphuric acid drying and fusion, the gold recovery methods being of the usual nature.

With wise liberality, the managers have completely duplicated practically the whole of the plant. There are two crushers, two sets of high-speed rolls, two revolving dryers, three ball-mills, with provision for a fourth, two elevators, two agitating plants, and three filter presses. The plant is the embodiment of the latest designs and methods extant, and the manual labour involved is reduced to a minimum. The process is to a great extent quite automatic. The ore passes from the bins to the crusher, from the crusher to the rolls, from the rolls to the dryer, and from the dryer to the ball-mills without human handling. The contractors undertook to build the plant capable of treating 100 tons per day. This, it has been proved, it can easily do.

A description of this mine would not be complete without a word of reference to the circumstances under which this new plant was installed. The contractors, The London and Hamburg Gold Recovery Co., did not undertake the work of setting up this magnificent plant on ordinary financial terms. So great was their confidence in the mine that they accepted £40,000 worth of shares in exchange for the plant, taking, what was described at the time, as the greatest industrial risk ever carried by one firm in the colony.

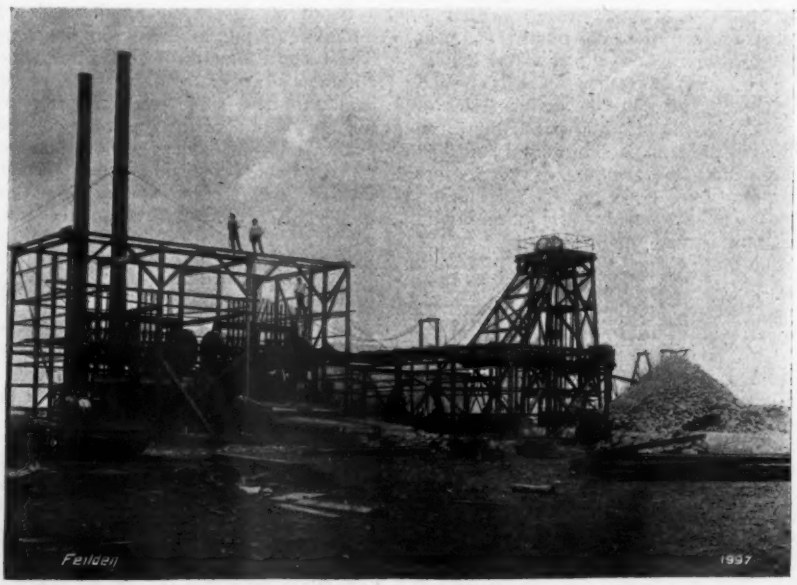
THE GREAT BOULDER PERSEVERANCE.

In a recent conversation which the writer had with the secretary of this company it appeared that the engineer at the mine is sanguine of making it *the* mine of Kalgoorlie; but, then, mining engineers are a sanguine race. Nevertheless there is no doubt that the prospects of this property are exceedingly good, and providing the management remains in the same able hands it is quite likely the mine may take a very prominent place in this field.

With regard to the machinery, everything which money and care can accomplish has been done, the following being an official description of the plant:—

The ore is delivered at the main shaft direct from plat over a trestlework to grizzly, the fines passing over a second set of grizzlies to two No. 3 Gates crushers, while the coarse product goes to a No. 5. Gates breaker, the whole product from these crushers going to a large storage bin with a capacity of from 1,000 to 1,200 tons. The power for crushing is supplied by an electric motor of 60 h.p. There is also additional steam power at this point which can be used in case of stoppage of motor from any cause. This steam power, when not in use for crushing, is used for operating a small saw-mill. The main ore bin is supplied with chutes on two sides. The chutes on one side deliver to an endless belt conveyor (Robins type), which in turn deliver to ore bins which connect with dryers, or deliver direct into cars (in case the ore does not require drying). These cars run on a trestle at the back of the Griffin mills, and deliver into bins which deliver into feed hoppers to the Griffin mills. In case the ore is put through dryers, it is delivered direct in trucks which are run on to a platform lift, and the trucks are taken off lift on to a trestle, and the ore dumped into Griffin mill bins.

There is another way that ore may be taken direct from the main ore bin in trucks from chutes on opposite side of bin. It is then trammed on surface and the trucks placed on the same platform elevator, then over trestle to Griffin bins. This gives a second and independent way of conveying the ore to the Griffin mills. These mills are driven from main counter shaft from the large mill engine (Corliss type). They are arranged in a line, and the product, which is delivered in a cone-shaped hopper under the mill, is in turn conveyed in a horizontal iron tube by means of an archimedial screw conveyor on to a broad horizontal belt conveyor.



THE LONG REEF GOLD MINING CO., LTD.: BATTERY IN COURSE OF ERECTION.

This conveyor delivers into the boot of a vertical cup belt elevator, which in turn delivers into a storage bin with a capacity of 350 tons. From a chute in this storage bin the ore is again elevated with cup elevator to a Robins belt conveyor which delivers into the feed hoppers of the four Holthoff Wethey roasters, the ore being taken off at the side to supply the feed hoppers of each of the four furnaces.

The Roasting Furnace (Holthoff Wethey) is a straight line mechanically operated furnace with cooling hearth underneath furnace. The hearths are 12 ft. wide by 120 ft. long. The rabbles are fixed on the top and bottom of the rabbling arm, and one set of rabbles drags the roasted ore through the furnace, and the returning rabbling is effected by the same rabbling arm with the rabbles on opposite sides of the same, the cool roasted ore being delivered at the same end of the furnace at which it is fed. This cooling is effected by the air, the roasted product being constantly turned over as it is dragged over the cooling hearth.

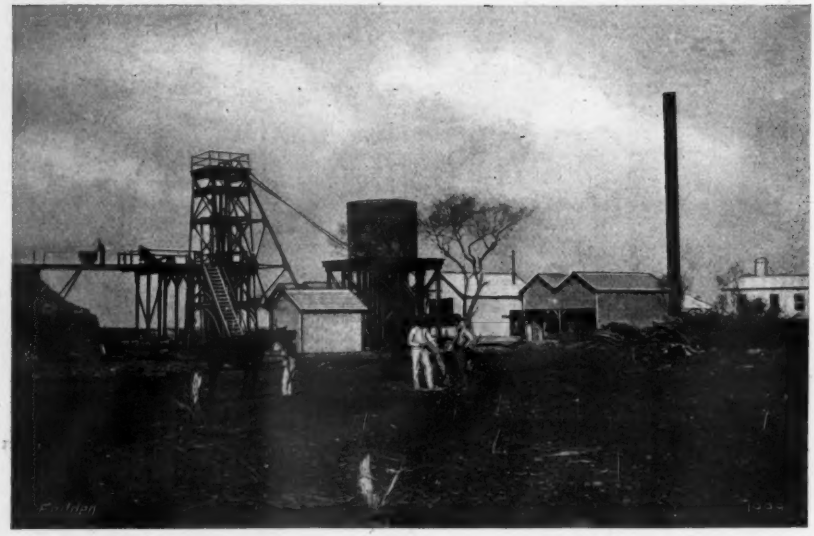
The roasted product is delivered into a V-shaped trough and conveyed with archimedial screw to the boot of an elevator at each furnace. These cup elevators deliver into a launder, and sufficient water is turned in to carry the pulp through a series of launders to the grinding pans, where the whole of the pulp is subjected to amalgamation and fine grinding of the product that may have gone through the Griffin mill (by long experience it has been found that only a very small percentage of the Griffin mill product goes through the mill that will not pass a 100-mesh screen or finer, and this product, ranging from 1 to 10 per cent. of the whole, is ground in the pans). There are eight pans, 8 ft. in diameter, 4 ft. deep, cast-iron bottoms and wrought-iron sides. The pans are provided with quicksilver well and amalgamated copper wings. The pans have a continuous overflow, and the pulp runs over a series of copper plates, and is delivered through launders to agitation vats, 24 in all, 20 ft. in diameter and 4 ft. deep. These agitators are operated with gear from below, and the driving gear is similar to that used in pans. The cyanide process begins at this point. After agitation in vats, and washing and decantation, the whole product is passed into filter presses of the Dehne type. The tailings are thrown out, and the solution goes through precipitation vats, where the gold is extracted with zinc dust. The zinc sludge is then caught in small filter presses, the excess of zinc dissolved with sulphuric acid in lead-lined vats, and the gold melted into bars.

THE LONG REEF GOLD MINING CO., LTD.

This is an important mining company holding several leases at Mount Magnet, in the East Murchison Goldfield. The properties consist of the Long Reef, Long Reef North, Long Reef South, Wheel of Fortune, and Wheel of Fortune South, having a total area of 51 acres. There are two principal reefs on the property, which have been extensively opened out by drives at 100 and 200 ft. levels. Developments on a promising-looking cross-reef are also now in hand. The main shafts both on the Long Reef and Wheel of Fortune leases have now attained a depth of 300 ft., at which level it is intended to put in drives on the veins. The battery consists of 20 stamps, which commenced operations in June of last year, and have since treated 17,783 tons for an output of 13,170 ozs. of gold, exclusive of that contained in the tailings, to treat which a cyanide plant is being erected and is now approaching completion. There is an abundant water supply. The Geraldton-Cue Railway passes within a few hundred yards of the property, enabling supplies of stores, etc., to be obtained very cheaply. The cost of mining and milling, including proportion of administration and general expenses, amounted to an average of 27*s.* 9*d.* per ton during the year ending June 30th last.

EAST MURCHISON.

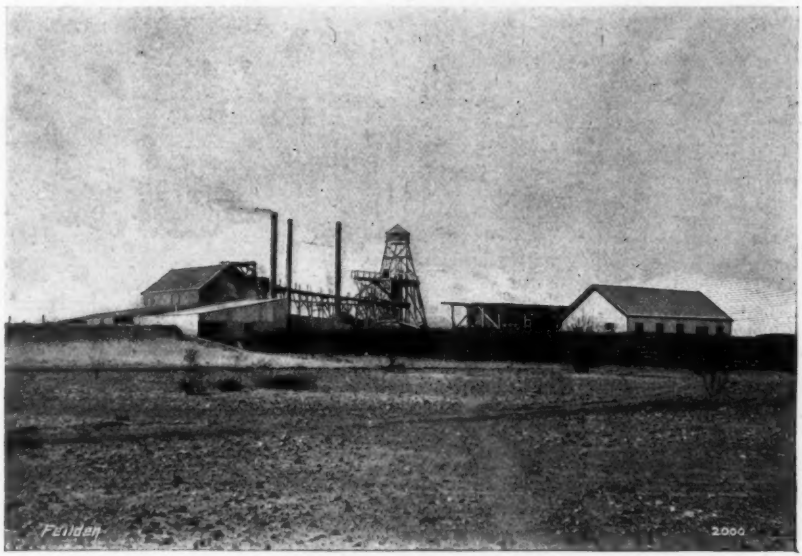
It is noticeable that so important a mine as the East Murchison United should be at the distinctly inconvenient distance of 120 miles from the nearest railway station. To those disposed to be particular in geography it may be remarked that the



THE LONG REEF GOLD MINING CO., LTD : BOILER-HOUSE AND MAIN HEAD-GEAR.

mine is about one mile east of the township of Lawlers, and about 250 miles east of Cue. One of the London and Western Australian Exploration Group, it was purchased by Messrs. Bewick, Moreing & Co. in 1895. The following year a ten-stamp Sandycroft battery was put up, and an additional ten stamps in 1897. It may be imagined that the cost of hauling such heavy machinery over 120 miles of roadless country was immense. But the confidence of the directors was well justified by the result. It was evidently a case of failure or success, according to the good or bad management of the undertaking, and the mine is a conspicuous example of how mechanical difficulties inseparable from a new country can be overcome.

In October, 1897, Messrs. Bewick, Moreing & Co. assumed active control of the property, at which date the cost of mining and milling was £2 9*s.* 6*d.* per ton. They reduced this in somewhat less than a year to £1 1*s.* 11*d.*, and later to £1 1*s.* This is about the lowest figure yet attained in Western Australia. Two principal veins of ore run through the property, called respectively the Great Eastern and Lawlers. A percentage of these is extremely rich, and a larger percentage is not. So the high-grade and the low-grade ore are judiciously mixed, to give an average of 1 oz. 5 dwts. to the ton, or as near that as practicable. This is considered a fair average of the whole lot of ore in sight. The veins are here and there of regal breadth, touching 17 ft., and running down to 3 ft. 6 in. A drawback to deep-level work, very unusual in Australia, is the quantity of water found at comparatively high levels. This, of course, means a lot of pumping. But the compensations are great. The water which the East Murchison pumps to the surface is guided to convenient spots, where the miners and others use it to irrigate garden plots. This circumstance makes the lives of the employés far pleasanter than at most Westralian mines. Fresh vegetables can be grown in abundance. When the railway *viâ* Menzies is so continued as to bring the East Murchison field in touch with the railway system of the colony, there will be



EAST MURCHISON GOLD MINE: GENERAL VIEW.

no district with a brighter future before it. A line to Mount Leonora, and thence to Lawlers—a scheme supported by Sir John Forrest—will no doubt soon be an accomplished fact.

THE SONS OF GWALIA.

As may be imagined from the name of this mine, enterprising "gallant little Wales" had something to do with its discovery. A party of Welshmen, prospecting around Mount Leonora, found and pegged out the claims which they thus named. The fame as a gold-bearing district which Mount Leonora has achieved rests mainly on the discovery of these lucky prospectors. The ore deposits are of two kinds—lode formations and quartz veins. Both varieties have a north-south strike and a dip of about 50 degs. to the east. The country rock is an argillaceous slate, dipping and striking parallel to the lodes. The deposits are very similar in origin and nature to those of Kalgoorlie. The Sons of Gwalia claims are on the slopes of the mountain, and about 68 miles north of Menzies. The quantity of payable ore already exposed is estimated to be sufficient to supply a 50-stamp battery for several years to come. A particular advantage of the property is that a good supply of water is available for mining purposes at a depth of 60 ft. At first a colonial-built 10-stamp battery was erected, which, though it did fairly good work, soon proved inadequate to the requirements of the mine. During last year, however, an up-to-date equipment was partly installed and is now complete.

The main incline shaft has been driven to about 700 ft. on the incline, and is large enough to carry skips of a capacity of five tons. The main vertical shaft is 314 ft. It will not be sunk lower, owing to the great length of cross-cut necessary to cut lode at another level. In addition there is the south shaft, 131 ft. deep, and Hooper's shaft, 122 ft. deep. The new machinery includes a 30-head stamp mill of the most modern design, with extra long amalgamating plates, and the installation comprises hoists, large ore bins, Wilfley concentrators, a tailings wheel, a pneumatic tailings lifter (as an emergency elevator),

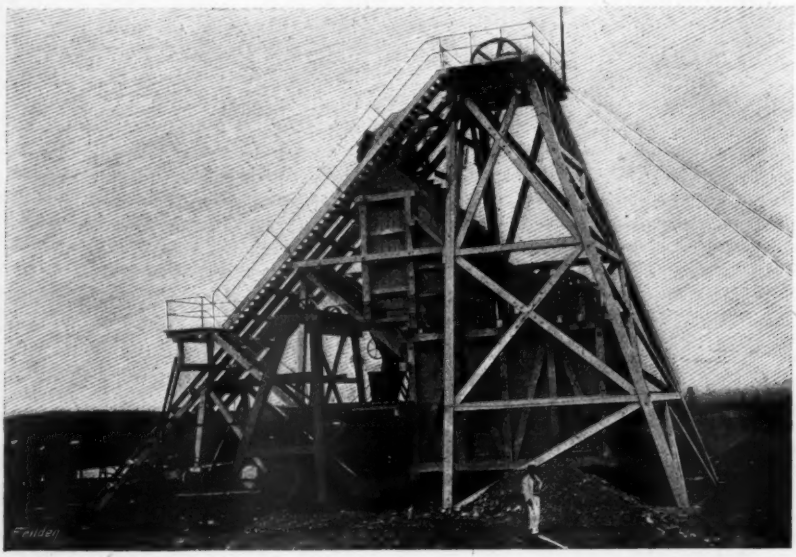
and a complete cyanide plant capable of treating the sands from a 50-stamp mill. There are points about the incline shaft outfit also which are worthy of particular mention. The direct-acting winder, with cylinders 16 ins. by 36 ins., and drums 6 ft. in diameter, is capable of winding from 3,000 ft. The head-gear carries continuation of shaft truck, and is arranged for self-dumping skips, delivering into large bins in head-gear. The ore, on its discharge from skips, passes over grizzlies (the larger product through Blake-Marsden crushers), and then into large storage bins —all within the main framing.

Owing to the isolated position of the mine it was found necessary to equip the machine and smiths' shops very thoroughly. There are lathes, a shaping machine, drilling machine, screwing machine, and other similar machine tools. This department was essential to the proper erection and maintenance of the plant. An important part of the works is the air-compressing machinery. It is of 6-drill capacity, and a large part of the power is used for sinking pumps. Then there is a condensing plant for the supply of water for domestic purposes, Nature having been niggardly in the supply of really potable liquid.

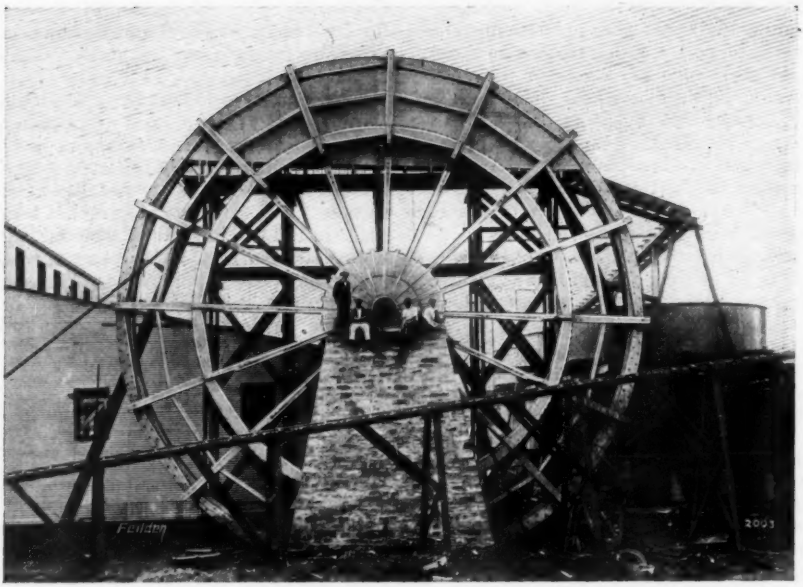
Last, but most important of all, is the central steam plant equipped with Babcock & Wilcox boilers, fuel economisers, and a Davey, Paxman engine of the latest design. Simultaneously with the installation of this new plant, extensive progress has been made in the development of the mine, and during last year 7,086 ft. of sinking, driving and timbering were completed. The yield of gold has been satisfactory, 18,448 oz. having been won from 17,655 tons of ore.

THE ASSOCIATED GOLD MINES OF WEST AUSTRALIA, LIMITED.

Notable among the parent companies is "The Associated," which holds an extensive area in Hannan's field, and has nursed several hopeful bantlings with more or less success. In 1898 the company went in for deep sinking operations upon the "Australia" leases and made important discoveries of oxidised, sulphide and telluride ores. The history of the



THE SONS OF GWALIA, LTD.: MAIN SHAFT HEAD-GEAR.



THE SONS OF GWALIA, LTD.: TAILINGS WHEEL.

company's operations, mechanical and financial, are interesting, but would demand more space than can be spared in this article. It may, however, be mentioned that for the year ending last March the value of the bullion produced and sold was £355,742.

Respecting the equipment of the mines which the company is working, the following are the most recent particulars available and within the cognisance of the London staff, but as the result of a change in the management and staff at the mines some alterations and improvements are now in course of being made. In the sulphide mill, the method of treatment is in this wise: the ore being brought to the ore bins, the coarse pieces are broken in four "C" size Comet rock-breakers. The whole of the material then passes through Roger's crushing rolls—four of them—and is crushed to pass through a half-inch mesh. It then passes through revolving dryers and is afterwards elevated to bins from which it is passed to ten Krupp ball-mills, where it is crushed to pass through a screen of perhaps 20 holes to the linear inch. Afterwards it is roasted in four Ropp mechanical furnaces, after which it is cooled by passing through mechanical coolers, and is ready for the cyanide treatment, for which 24 steel vats of 200 tons capacity each with solution tanks are provided. The capacity of this mill is about 400 tons of sulphide ore per day. The power is supplied by a 500 h.p. compound engine with six 200 h.p. water-tube boilers. An overhead wire roadway, locally called a "flying fox," is used for the cheap handling of the ore. It carries a load of one ton from the mine to the mill, making 20 trips an hour.

HANNAN'S PROPRIETARY DEVELOPMENT CO., LTD.

The proprietors of numerous leases in the neighbourhood of Kalgoorlie and holding large interests in sundry subsidiary companies, this company, with a paid-up capital of £495,000, is one of the most

notable in the colony. Upon the Hannan's Field it possesses about 366 acres, distributed over a wide area. The leases known as the Oritava group (containing the Golden Pheasant North and the Adeline groups) are in course of vigorous development. On the Golden Pheasant North a shaft has been sunk to the depth of 850 ft., and another to a less depth on the Adeline. These shafts have disclosed certain bunches of valuable ore, and a large lode formation about 40 ft. wide. It is intended to work down to 1,000 ft., and then cross-cut by means of a diamond bore.

The reserves are stoped out to last for about 12 months longer, during which time it is expected that the further sinking of the shafts will disclose large and valuable deposits.

Hitherto the policy of the directors has been to create subsidiary companies in order that they may, with working capital provided by themselves, explore other portions of the property on leases so situated that, being in the centre of other leases belonging to the parent company, the latter will learn where to look for good results. Hannan's Proprietary is interested in the Golden Pike, which has been amalgamated with the Lake View East. In the former there is stated to be an enormous lode formation 110 ft. wide. It contains patches of very rich stone, but, upon the whole, it is not quite up to paying point, and will have to be left to the day of greater science in the art of gold extraction than we now possess. Another mine which must be reckoned in the assets of the company is that of Ironsides North (taken up by an Australian company.) On this property at the 310-ft. level a lode of 18 ins. wide has been found worth 3 ozs. to the ton.

The parent company is also interested in the Hidden Treasure, a mine near to the Ironsides, but work there is suspended until further development on the neigh-

LEACHING VATS AT THE ASSOCIATED GOLD MINES, W.A.

bouring properties indicate more definitely the prospects of the lease. Then there is the Oroya East, a subsidiary company floated last year. The managers of the mine intend to sink a shaft to 500 ft. in the hope of striking the valuable deposit found in the adjoining Brownhill Extended. There is still another lease belonging to Hannan's Proprietary—the Golden Chain—the surface rights of which have been sold to a company which is going to put up a sulphide plant forthwith.

It is considered by the directors of the parent company that the gold won will almost wholly pay for the developments now being pursued, and that there are excellent prospects of valuable discoveries on one or other of the several leases. It is a feature of this part of the Kalgoorlie field that deep sinking is frequently the most profitable plan to follow, but obviously this work takes a greater time to bring actual profit than in those mines where the payable stone is at a higher level.

A sensational incident in connection with this company was the discovery of alluvial gold upon the "Successful" and "Albion" leases. A rush of diggers set in, and, despite the fact that by an Act of the Colonial Parliament which had recently been passed, their action was completely and distinctly illegal, they proceeded, to the number of 3,000 (all more or less armed), to peg out the ground on these leases and set to work on the gold. A section of the colonial Press supported the diggers, and the difficulty quickly assumed national importance. Mr. Harris, the representative of the company on the spot, exhibited conspicuous courage and tact under the trying circumstances in which he was placed, and eventually, when persuasion and remonstrance had been exhausted, the Government were called upon for effective assistance. A large force of police were drafted to the ground, and after a good deal of difficulty the trespassers were ejected. In the legal proceedings which followed the judges decided, in every case, that the mining company was in the right.

CONCLUSION.

Many another rich and flourishing mine might be added to those I have particularly referred to, especially so if the smaller fry were included—and it is not always the biggest mines that warm the hearts and fill the pockets of their shareholders. I will run through little more than the names of some of those not yet mentioned. An extensive and profitable company is the Golden Horse-shoe Estates Co. Ltd., holding property at Hannan's Find in the Coolgardie field. In the same district is the White Feather Main Reefs, whose crushing commenced in 1897, and has been going on merrily ever since. Another mine in Hannan's district is the Golden Link Consolidated, which, registered in 1896, was an amalgamation of the Eclipse, the Golden Link, the Hesperus, and the Great Boulder East Extended. Again, at Hannan's, a notable Co. is the Great Boulder Proprietary, paying handsomely, and having a protégé in the Great Boulder No. 1 Ltd. Many more might be included in the list of producing mines.

In concluding this brief review of the Westralian gold mining industry, I find myself somewhat in the position of the boy at the feast, who wept because he could eat no more. My good friends the secretaries and directors have loaded me up with a rich store of information which I should be delighted to arrange for the delectation of FEILDEN'S readers. But alas! I have no more room. Editor and printer are alike inexorable, and, sadly admitting there are many things omitted which might well have been included, I would deprecate the criticism of the exacting. What is writ, is writ—not a strikingly original observation, but accurate beyond suspicion.

G. E. R.

Economics of Coal Mining.

By L. W. DE GRAVE.

MR. DE GRAVE commenced life as a mechanical engineer, going through the pattern, fitting, turning, erecting, boiler shops and foundry.

The rapid advance made by electricity induced him to turn his attention to this branch of engineering, a considerable amount of experience being obtained in the theoretical part of the subject at the Finsbury Technical College.

In 1890 he joined Messrs. J. Davis & Son, of Derby, as assistant engineer, his attention being turned to the application of electric power to colliery requirements.

In 1893 he became managing engineer for the same firm, in which capacity he designed the largest electric haulage plants in the country, in addition to introducing systems of auxiliary haulage and pumping plants for recovering flooded pits.

The trouble in the colliery labour market in 1893 emphasised the necessity of machinery for coal-getting purposes. This resulted in the taking up of the Jeffrey heading machine, a number of which have been installed at home and abroad; but this type not being altogether suited to the general condition of English methods, the Longwall machine was designed and put to work.

At an early date he recognised the large field of usefulness for special slow speed electric motors for driving machine tools, cranes, etc., in engineering works and ship yards, and designed and built a variety of sizes both open and enclosed.

As a mining engineer his experience of mining machinery has been of the utmost service, and his experience of colliery accidents probably unique.

In purely scientific research he has paid much attention to the application of electricity to the development of the photographic latent image and colour photography with some considerable success.

He is an occasional contributor to technical and scientific literature.

IN every industry dealing with necessaries, it is the relation between demand and supply which practically fixes the selling price; so that coal should get cheaper the more tonnage is put on the market, unless the demand keeps pace with the supply, which is the case at the present moment.

A pit with a large output will almost of necessity produce its coal cheaper than one with a small output: labour troubles generally come heavier on a small concern than a large one, and small outputs have a tendency to work their own destruction by causing bad roofs and a consequently increased cost for timber and upkeep, for the sole reason that the workings do not "travel" fast enough. It is perhaps not very premature to say that the very existence of the majority of pits under 500 tons per day output is threatened.

The whole question is one of cost *versus* selling price, and when the former gets nearly equal to the latter it is time the work was stopped; but, before such a state of things comes about, the possibility of reducing cost should be considered, even though it necessitates an increase in capital outlay.

Commencing at the far end: "coal-face" costs claim the first attention, and every pit has to answer its own question

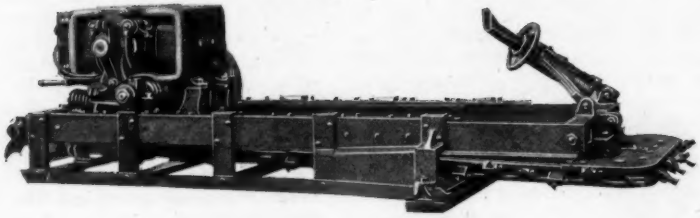


FIG. 1.—ELECTRIC HEADING MACHINE CHAIN CUTTER.

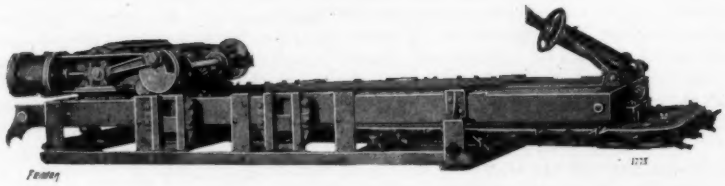


FIG. 2.—AIR-POWER HEADING MACHINE FOR LOW SEAMS.

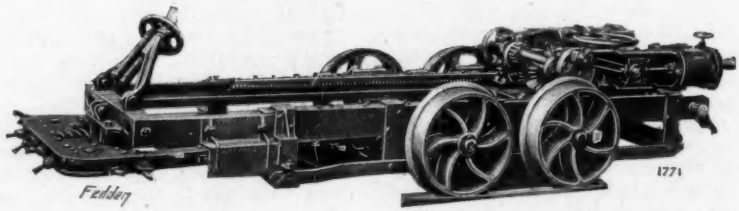


FIG. 3.—AIR-POWER HEADING MACHINE FOR LOW SEAMS ON TRUCK.

as to the reason of its more or less heavy coal-face costs. The principal reasons are probably as follows :—

1. Scarcity of men (the coal hewer is rapidly becoming extinct), and obstructive combinations of workmen mean not only reduced output, but possibly large areas of coal face, unworked, falling in and costing large sums for upkeep.
2. Bad roof, travelling slowly and requiring an excessive amount of timber.
3. Hard holding, *i.e.*, a large number of men and a large extent of coal face for a given output, and a high cutting price.
4. Thin seams with high getting prices and a large percentage cut to slack in the getting.

It is interesting to examine these in detail, and see how far the employment of machinery will solve the difficulties.

Scarcity of hewers and obstructive combinations require no comment.

Bad Roof.—A bad roof is invariably improved by machine mining, the *rationale* being that, by travelling quicker, fresh roof is opened and packs are got on quicker than by hand labour; in addition to which the timber-cost is reduced—first, because not so much is required (the roof being made stronger); and second, the whole of the timber can be recovered from the waste before the weight nips it.

Thin seams with high getting prices.—Various conditions tend to make the saving in this case vary enormously. Experience has shown that in a 24-in. seam there is a saving to be effected of over 1*s.* per ton in the getting; but, leaving out of consideration the saving in getting, the economy effected by increased output, reduced timber, length of face to keep open, fewer gate roads, cross gates and main roads, has been the saving of 4*d.* to 5*d.* per ton, by no means a bad profit in itself.

This item does not altogether come under the coal face costs, but is so nearly

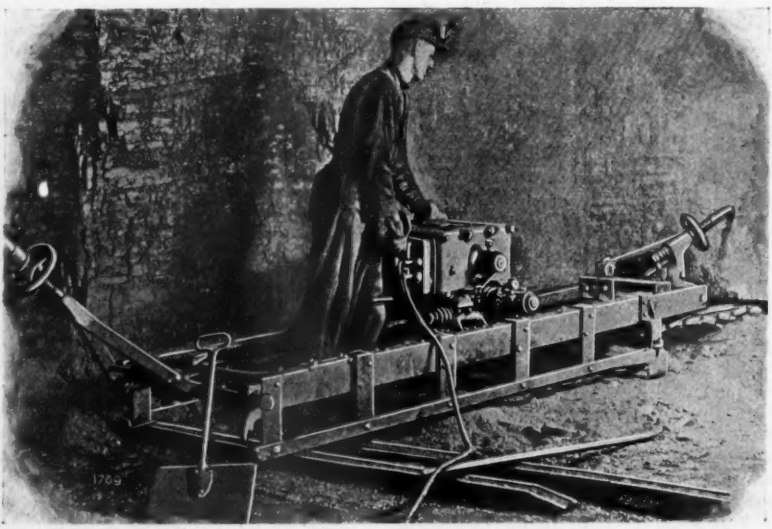
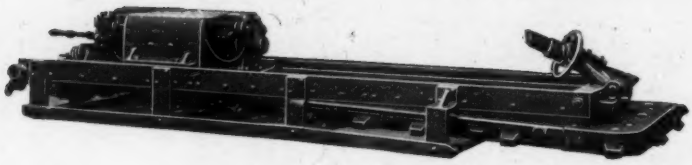


FIG. 4.—ELECTRIC HEADING MACHINE CHAIN CUTTER IN COAL.



1773 Feilden

FIG. 5.—ELECTRIC HEADING MACHINE FOR THIN SEAMS.

allied that a separate heading could hardly be made. In addition to above, a thin seam of tender coal will yield a large increase in the quantity of round coal when machine cut.

This brings one to Machines, their construction, use, and methods of setting out the workings, whether for pillar and stall, longwall or any combination or modification of these; and, as an example, it would be difficult to find a series of machines more representative or more suited to a variety of conditions than those known as the "Jeffrey," or better still, perhaps, in connection with the name of Messrs. J. Davis & Son (Derby) Limited.

Under the name "Jeffrey" are included three separate types of machines, each suited to a different purpose.

1. The "Header," for heading and pillar and stall work: Figs. 1, 2, 3, 4 and 5.

2. The "Shearer," for rib-cutting in headings and rooms: Fig. 6.

3. The "Longwall," for longwall faces: Figs. 7, 8 and 9.

The "header" covers two types, the rotary bar, in which the bar is driven by a chain from the motor, and in which cleaner chains are provided for removing the cuttings. This machine has been superseded by the "chain header" for some years now. There are, however, some 500 of the former in daily use. (The bar machine is manipulated in the same way as the chain.) The chain header has many advantages over the bar, the two chief of which are: 1st, it takes much less power (about 33 per cent.); and, 2nd, all the knives are the same shape, this being an important item in the sharpening and forging. As will be seen from the illustration, it is a breast machine, making its cut straight to the front. It can be operated either by electricity or compressed air, the difference being only in the motor. The principal parts are three in number: (1) the bed frame, which is the stationary part, being jacked both front and rear to the face and roof; (2) the sliding chain cutter frame, which, as its name implies, slides on the bed frame and carries the revolving chain in which are fixed the knives, these being all of the same size and shape; (3) the motor carriage, to which is fixed the motor and gearing, and which is attached to the sliding frame by steel castings.

The *modus operandi* is as follows:—The machine, mounted on its truck, is hauled to the face of the coal, the truck running on the rails or temporary track used for the mine tubs; the rear end of the truck is lifted and the machine slides off, reaching at once its proper position to commence cutting. Connection having been made with the electric cable or air pipes, and the frame firmly jacked, the machine is ready to start. The operator remains at the rear end of the machine, his work being practically at an end until the machine has finished its cut. He then reverses the gearing by means of a lever, and the cutter frame travels back until it reaches a point where it is automatically thrown out of gear. The machine is then ready to be moved for its next cut, which can be readily done by two men, the front end sliding on its own shoeboards, the rear end on the skid boards provided for the purpose: Fig. 4. In addition to the operator, one other man only is required, to set the front

jack, help shift the machine, and shovel out the slack. After the length of a face has been holed, the machine is again placed on its truck (this is easily accomplished by the two men in charge by means of the winch on the truck). A horse then takes it to the next face or stall to be holed, or for steep gradients a self-propelling truck is provided: Fig. 10.

The average time occupied from the commencement of one cut to the beginning of the next is from five to eight minutes, varying with the hardness of the coal, the depth of cut being up to 7 ft. by 44 ins. wide, about 4 ins. in height being removed. The machine will cut equally well in fireclay, clench or coal.

The average horse-power absorbed, as taken from a large number of readings in coal of varying hardness, works out at about 12, the weight being about 3,000 lbs.

The demand for a heading machine for thin seams, say 24 ins. to 36 ins., and one, moreover, which can be easily moved from stall to stall, has resulted in the construction of the machines as illustrated: Figs. 1, 2 and 5. This in construction is exactly similar to the "header" described above.

Great care has been taken, in designing this frame, to have it strong and rigid, so that there can be no bending due to the inequality of the floor of the mine when jacked down, thus doing away with the increased friction which must necessarily follow where a light, flexible frame is used. The weight of this machine is about 2,600 lbs.

Fig. 4 shows the chain machines at work in the mine. These two machines, bar and chain, are essentially "headers," or pillar and stall workers, although in a number of cases they are doing excellent work on longwall faces.

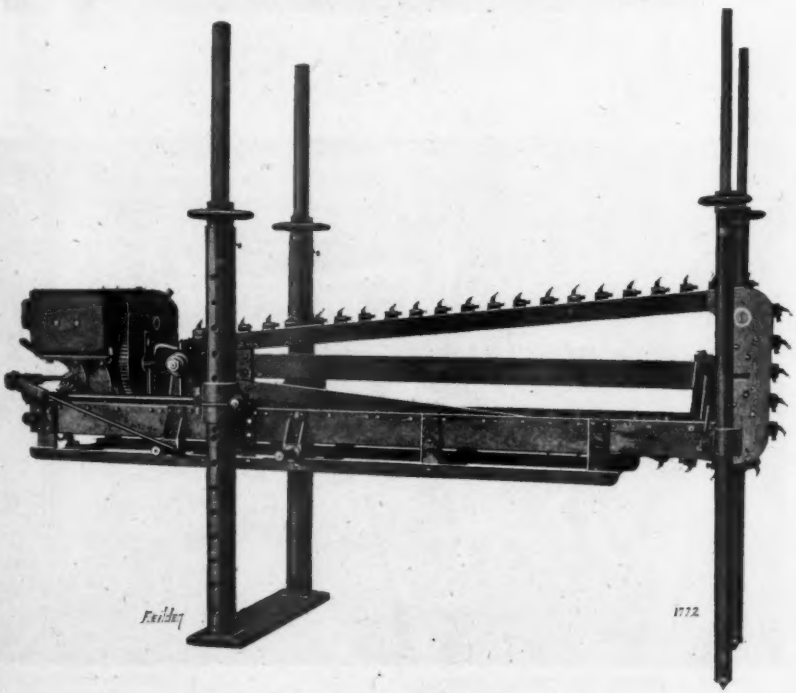


FIG. 6.—ELECTRIC SHEARING MACHINE RAISED ON JACKS.

FIG. 7.—ELECTRIC LONGWALL COAL CUTTER: SIDE VIEW.

FIG. 8.—ELECTRIC LONGWALL COAL CUTTER: FRONT VIEW.

The next "Jeffrey" is the "shearer," Fig. 6, for shearing in headings, rooms or entries, either before or after they have been holed. It will be noticed that there is a strong resemblance between this machine and the "header," the construction, as will be seen from the following description, being very similar.

The method of operating is to place the machine in position on the floor at the face of the coal, set and adjust the jacks in proper position, and raise the machine to top of the seam. The first cut being made at the top, the machine is lowered a distance equal to the cut (36 ins.) and is again in position to cut. This machine makes complete shearings from top to bottom of a 7 ft. seam of coal in 20 mins. This time includes placing it in position and adjusting the jacks, the cut being 7 ft. deep, 4 in. wide, and 7 ft. in height. Fig. 6 shows the machine in its middle position, and illustrates the method of support whilst making the cut.

The machine consists of three parts,—the bed frame, the sliding chain cutter frame, and the motor carriage. The bed-frame consists of two rectangular steel channel bars and two steel angle bars firmly fastened together by means of heavy steel braces. A heavy steel casting joins the channel bars at the front end of the bed frame and forms the jib or guide of the cutter frame. At the front extremity of the channel bars are riveted two lugs for supporting the split clamp for front jack. Between the centre and rear of the bed frame are the supports for main jacks. On each side of these supports are the bearings for truck wheels, which, in addition to offering support for the wheels, serve to make the frame more rigid. The cutter frame consists of one steel centre rail, a cutter head, and two steel guides in which the cutter chain runs. This portion of the machine has been designed especially with respect to rigidity and minimum wear and tear, it being the part which comes in direct contact with the coal. The motor is of the 4-pole type, with ring

FIG. 9.—ELECTRIC LONGWALL COAL CUTTER: REAR VIEW.

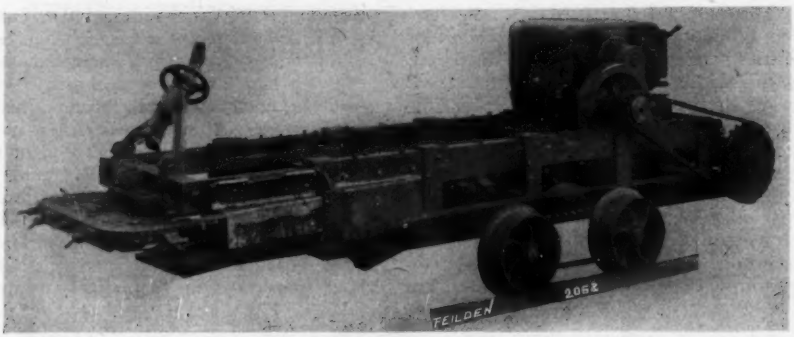


FIG. 10.—SELF-PROPELLING TRUCK.

armature and two field coils. The motor frame consists of one casting, forming a complete protection for the armature and field coils from falls of roof, etc. All parts of the machine are made to template and are interchangeable. They are also constructed for use with air power, the general arrangement being the same. Weight, about 3,000 lbs. for the electric, and 2,600 lbs. for air power.

The Longwall machine, Figs. 7, 8 and 9, it will be noticed, is a disc machine, and self-propelling. These two features are common to most machines of its class. The novel features are :—(1) That it runs on one rail only, the side thrust being taken by special sleepers and light screw jacks. The use of one rail overcomes the difficulty of rail-jumping, so common where two rails are employed. (2) It cuts its own floor, *i.e.*, cuts actually at floor level, but can be built to cut any height up the seam. (3) The cutting wheel may be tilted up or down by means of a hand wheel, as represented, so that obstacles, if met with in the coal, may be ridden over or loosened, or on an uneven floor the irregularities may be followed. (4) The machine is constructed to be driven from the front end. This enables the machine man to lay his rails and see that the coal and roof are safe before the machine approaches, and, moreover, leaves more room at the rear for the timberman to follow up and sprag the coal; it is, however, constructed to cut in either direction, that is to say, forwards or backwards, thus saving the labour of moving it when only short faces are available or when the roof will not admit of long faces being worked. (5) The feed shown in Fig. 7 is driven by an eccentric at the rear of the machine through a ratchet and pawl on to a haulage drum ; the novelty at this point consists in the arrangement which enables the feed to be stopped, started or adjusted without it being necessary to stop the motor. This is important, as it enables the machine to clear itself should it become clogged by a fall of roof. Three rates of cutting are provided, 8, 16, and 25 ins. per minute, thus enabling the same machine to cut the hardest clench or soft coal. (6) The whole of the machine is made of steel, and the gear wheels accurately machine-cut. The "high speed wheels" gearing the armature down to the cutting wheel and feed eccentric are enclosed in a casting arranged so that they run in oil. This gearing has received special attention, in the first place to reduce the wear and tear, and, secondly, to reduce the noise, the result being an enormous increase in the life of the gear wheels and such silence in running that the movements of the coal and roof can be heard whilst the machine is cutting. (7) All knives are straight, easily replaced without the use of screws or pins, and so arranged that the cutting strains take the form of compression and not shearing.

The whole machine is very compact,

being only 8 ft. 2 ins. long, 3 ft. 9½ ins. wide, and 19 ins. high. It cuts 3, 4, 5, 6, 7, or 8 ft. under, making a kerf of 4—9 ins. The motor, of 25 h.p., is free from sparking; the starting switch is completely enclosed, and the connections from the trailing cable to the machine enclosed with a metal cover. The weight is about 3,400 lbs. for the electric and 3,000 lbs. for the air power.

Another variety of the longwall has a bar in place of the wheel, the bar being provided with teeth and revolved rapidly. This is intended for those cases in which an exceptionally tender roof or coal requires support at closer intervals than the diameter of the wheel will allow.

The working of coal-cutting machines becomes a very simple matter once the "tricks" of machine, coal and roof have been learnt, and it is only necessary to draw attention to the following points:—1st. In the "header" the jacks, front and rear, require to be kept tight and the screws followed up after the cut has commenced. The longwall machine, unless cutting in hard stuff, does not require much attention to the jacking of the rails, but when cutting in hard material and with a soft roof, special care given to the tightening of jacks will save much trouble. The second point is the knives. These require designing to suit the material to be cut, and the proper arrangement of bottom, middle and top has to be ascertained. When this is done, the only other things to attend to are that all the knives project an equal distance, and that they are kept sharp; blunt knives are more often the cause of waste of time and loss of temper than that fruitful source of stoppage, bad roof.

When introducing machine mining it must not be taken for granted that the manager's anxieties are immediately decreased. As a matter of fact, unless he tackles them properly, his troubles are only beginning. Obstructive combinations of workmen, frequently countenanced by officials, have often resulted in the loss of several pence per ton, which might otherwise have been saved.

It therefore behoves the manager to give individual attention, in order to see that obstacles are not thrown in the way of the machine. This is the more desirable, as the treatment of roof and timbering is almost certain to be different from that required with hand labour, and an efficient, systematic, and cheap method of timbering has to be adopted. Fig. 11 shows perhaps the best form of timbering for longwall work, the cockermeg and face props being used or not, as the nature

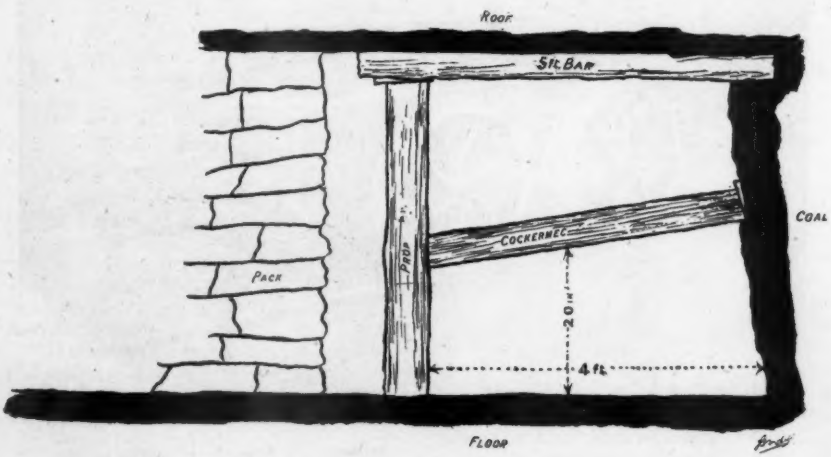


FIG. 11.—METHOD OF TIMBERING A LONGWALL FACE.

of the coal may require. It may be taken for granted that once the initial labour of introduction has been got over, and a good system adopted, the manager will find himself relieved of a great deal of anxiety. One peculiarity of iron men may be mentioned, and that is, they are not in the habit of asking for allowances when conditions vary slightly.

In setting out the workings for machine mining, except in virgin seams, previous methods frequently have to determine the method adopted. In pillar and stall work probably the best arrangement, if there is anything like a fair roof, is to cut rooms, say, 40 ft. wide, and leave 6 ft. pillars, everything else being taken out by the machine.

In longwall working long faces are desirable to reduce the labour of "flitting" the machine from end to end, the most economical arrangement for comparatively small areas being to work in a circle round the shaft pillar. But in setting out workings the first thing to consider is the direction of faults, if any, as these and their amount will frequently limit the possibilities. And secondly, whether the coal should be worked "end," face, or "board." This latter point has to be decided by the nature of the coal. In a strong coal, as far as the machine is concerned, it will probably not matter at all which way it is worked; this being so, the most suitable direction for getting down the coal decides the question. In a tender coal, or one which "blows," "end" will probably be the most suitable. In dealing with a slabby coal the direction should be chosen to prevent the possibility of a slab rolling over on to the machine (not that it will hurt the machine) and nipping the men, or at all events causing a stoppage whilst it is being cleared off.

The item of cost is the one probably of most interest to managers, and this varies according to conditions and the amount of time it is possible to keep the machine at work. A chain header employed in driving only one heading 3 yds. wide (*i.e.*, three cuts) in a 4-ft. seam

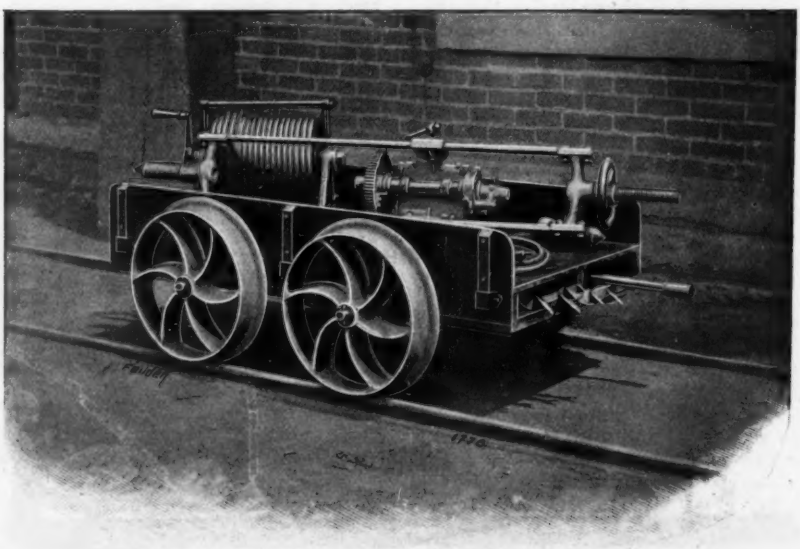


FIG. 12.—TRUCK CONTAINING ELECTRIC DRILL WITH FLEXIBLE CABLE ON REEL.

FIG. 13.—ELECTRIC DRILL IN MINE.

(getting into position, making three cuts, each 6 ft. deep, and getting away again) only half-hour in every twelve is saving over 5*s.* per yard;* and of course it will be readily seen that, if there were other headings or rooms in the district, the one machine could be kept more fully occupied, and give a better return for capital outlay.

The following excerpt from a report of an Indian colliery, referring to the working of a Jeffrey header, working pillar and stall may be of interest. It will be noticed in this case there is no saving at present in labour—all stores and repairs included in this item—but those acquainted with Indian mining will understand that the first requirement is increased output per man employed:—

"During the two months mentioned the machine undercut a total of 4,232 tons at an average cost of 1 rupee per ton. I may state that this cost can be reduced, as the quantity of work done during the two months was not nearly up to the capacity of the machine. This cost includes all labour (European or native) employed on the machine, stores, etc., necessary for the working and keeping of the machine and the whole of the electric plant in repair. The cost, it will be noted, compares favourably with hand labour, which also works out at 1 rupee per ton. The advantages of this machine may be stated as follows:—

"1. Its working cost per ton of coal undercut is very favourable compared with hand labour.

"2. A large output can be got from a small working area, *i.e.*, from a very few galleries. Twelve galleries are sufficient to keep one machine working and cutting six hours per day. Therefore twelve galleries can be made to give 190 tons per day against 48 tons from the same number of galleries working by hand labour, or four times as much.

"3. It economises labour at least 50

* This saving has since been increased to 7*s.* by adopting a system recommended by the writer, of overlapping shifts.

per cent. Very few skilled miners are required, only for such work as drilling, blasting, and dressing. Any class of labour can be employed to load and team the coal, thus the miner is left available for other coal cutting.

"4. The machine is easily handled and fixed in position. Six natives with a supervisor (European or native) only employed in working and shifting the machine about.

"5. The machine undercuts the coal with great ease and rapidity. One cut 3 ft. wide and 6 ft. deep can be made in from 3 to 4 mins. after the machine is fixed. Two galleries, each with four cuts 3 ft. wide and 6 ft. deep have been undercut in 8 hrs., including shifting the machine from gallery to gallery, and fixing it in position for every cut.

"6. Two galleries undercut in a 20-ft. seam (but allowing only 17 ft. in height to be cut) in 8 hrs. will make six galleries in 24 hrs. Six galleries undercut 12 ft. wide by 6 ft. deep and 17 ft. high gives a total of 264 tons undercut in the 24 hrs. From this quantity 25 per cent. should be deducted, to include stoppages for repairs and other causes. The capabilities of the machine may therefore be safely stated at 190 tons undercut daily, or in round figures, 5,000 tons per month under the conditions already mentioned. The quantity undercut will, of course, be correspondingly more or less, according to the thickness of the seam. It should also be stated that the number of galleries undercut will depend on the gradient of the seam. In our case ii is 1 in 5. In a flat gradient the machine should exceed the above very considerably, as the greatest part of the time is spent in moving the machine, especially up the gradient when it is very steep.

"My experience of the working of the Jeffrey machine has been very favourable, and I can highly recommend its adoption in any colliery where labour is scarce, gallery room is limited, and increase of output desired at the lowest minimum cost.

"I can highly recommend the two Electric Drilling Machines supplied. These machines are light, easily handled and fixed, and drill a hole 5 to 6 ft. deep in less than a minute. This machine facilitates the blowing of the coal and the preparing of the galleries for the coal cutter."

Mr. W. S. Gresley, of the Youghiogheny River Coal Company, Pittsburg, in his paper communicated to the Institution of Civil Engineers on "Central Station Electric Coal-mining Plant, in Pennsylvania, U.S.," where he has sixteen Jeffrey electric chain coal-cutting machines under his care, says:—"All things considered, the coal-cutting portion of the outfit is paying at least 50 per cent. on the original investment."

He also shows that the coal-cutters produce one and a-half times as much per head per day, compared with manual labour, at a cost of half as much for blasting and loading, at a cost of one-eighth as much for under-cutting, and a saving of 4½*d.* per ton of 2,000 lbs. of coal, with an increase of the yield of round coal.

In a paper published in the Transactions of the Institute of Mining Engineers by Mr. Williamson (Cannock and Rugeley), a saving was shown of 5½*d.* per ton with a "Jeffrey bar-header" on a longwall face and an increase of 12 to 15 per cent. of round coal;—this in a 5-ft. seam of coal.

The writer has not at present any data referring to the shearing machine which he would care to give as exact. It may, however, be sufficient to say that it represents a saving of over *2s. 6d.* per yard in those cases where it has been the practice to hand-shear, and when no hand-shearing has been done—the coal being under-cut and blown down—a saving of over 40 per cent. of round coal.

Working with a longwall machine in a 3-ft. seam, strong coal, bad roof, cutting 5 ft. under in dirt and coal—the latter containing about 70 per cent. of pyrites—there is a saving of *6d.* net in the getting price, only a few per cent. more round coal—holing by hand was done in the dirt—and an increase of coal from 4 to 10 tons per man (colliers and machine men). This *6d.* by no means represents the whole saving. It is further of interest to state that the machine is at present run on day labour, and that previous to machining it was impossible to keep 20

yards of straight face, and now there is nearly 500, which will shortly be extended to 1,000 yards.

A point, to which has hardly been paid sufficient attention by those who have adopted machines, is the depth of undercut. There are very few seams which are not the better for being holed 5, 6, 7, or 8 ft.; 4 ft. 6 in. should be the very least except in very special cases. Anything less than that, to use the expression of a well-known colliery manager, can be done more economically by turning in a lot of hens to scratch. This may not be literally true, but there is a great deal in cutting deep and doing less (lineal) yardage. A striking instance may be cited of a saving of 1*d*. per ton by increasing the depth of holing by 6 ins.; and, looking at it from a point of view of labour only, it will be seen that the same rail-laying which does for an undercut of 3 ft. will do for one of 5 ft.

A system of longwall machine-mining which has much to recommend it is the driving by machine of "leading places" say 20 or 30 yds. wide, in advance of the longwall faces, and, say, every 100 yds. apart. The advantages of these leading places will be readily seen. They give timely notice of any unknown upheavals or faults, and thus prevent a number of longwall machines being thrown idle all at once, there being sufficient notice of such disturbance to enable other places to be prepared for them. The advantage of the longwall machine cutting into a heading instead of up to rib is also considerable. An ordinary 3-yd. heading would, of course, be sufficient for this purpose, but by driving 20 to 30 yds. wide there is sufficient coal to "go at" to make machine-mining with a "header" nearly as profitable as with a longwall.

The distance at which gates should be kept open is an important consideration, but one that depends so absolutely on conditions that it is hardly possible to say much on the subject except that they should be driven as far apart as convenience in filling out the coal quickly will admit of, 20 to 40 yds. being about the minimum and maximum respectively.

Figs. 12 and 13 show the drill, which is an extremely useful tool to follow a cutter in those seams where blasting has to be resorted to. They are adapted for use in both bituminous and anthracite seams, and form a very simple piece of machinery, with few parts, and, moreover, can be operated and moved from stall to stall by one man. The machine will drill a hole 6 ft. deep, 2 in. diam. in about 60 seconds.

L. W. de Grave

The Mines of the Transvaal.

By G. EMERSON RUSSELL.

❀ ❀ ❀

THE GENERAL SITUATION.

ANY writer who had the effrontery to throw at the head of the British public the briefest history of the Transvaal, without giving a dominant place to the war and its consequences, would, at the present juncture, deserve to take the consequences of his readers' fury. I will not do this. Neither do I propose to enter into the maelstrom of controversy which has already overwhelmed some respectable reputations. I shall not discuss the war, nor the War Office, nor the strategy, nor the hospitals, nor the generals, nor the rank and file, nor anything which is theirs. Even if the public were not getting just a little weary of it all, I would not do so. It will be sufficient to touch, by way of introduction to this brief account of the Transvaal mines, upon certain facts and circumstances having a direct bearing upon the mining industry of the country; dealing with the past only in so far as it may perchance throw a dim light into the future.

One, and not the least, of the banalities of war is that all other matters antecedent are obscured and distorted. In the Mother Country the true position of affairs in South Africa before the war with the Republics will be appreciated by very few. Glancing first at the character of the Boers themselves, their attitude in the future is a subject having first-class political importance. It is also a case where politics and economics cannot be dissociated. If the Boer proves to be absolutely unforgiving, revengeful, irreconcilable, and treacherous, his influence on the commercial and industrial progress of the country will still be seriously detrimental. Such an attitude will mean a permanent military occupation and a huge police force. Both institutions are extremely expensive. Taxation will have to be high in order to meet such expenditure; and heavy taxation is just what the mining community of the Transvaal has been complaining of all through the tragedy. And what are the probabilities? These Dutchmen of the two ex-Republics, whatever else they may be, are men passionately loving their liberty and saturated with their nationality, furiously resenting British interference, and prepared to adopt any expedient—force or fraud—rather than submit to absorption and the domination of the English.

A great deal of sanguine and complacent nonsense has been written on the assumption that the Boer, so soon as the war is over, will philosophically go back to his farm, will become quite tractable, and will transform himself into a good British colonist. He will be tractable much in the way that a tiger is tractable that has had its teeth drawn and is emaciated by hunger. So far, then, as the Boer is concerned, it is highly improbable that he will be anything but a hindrance at best. If the present generation can be so tactfully treated their capacity for obstruction will be minimised and their talent for intrigue rendered futile; that is the best which can be hoped for. With the rising generation of the Boers things will be altogether different. Many, doubtless, will absorb and maintain the anti-British prejudice and race-hatred of their fathers; but it is to be hoped they will be in a small minority. That Dutch and British can live and work side by side, and marry and give in marriage, has already been proved in Cape Colony, and even in the ex-Free State.

Turning to the material resources of the Transvaal, and assuming that the Government of the future will be an honest, a sane and not too expensive institution, the outlook is distinctly bright, and if one lets one's imagination "go," it appears dazzling. Foremost among the important problems which will have to be solved is that of

labour. So soon as the mining managers get back to the scene of their labours, there is every probability of labour being plentiful. The sources of supply have been dammed by the war, and when the mines once again are in a position to offer employment, there will be a rush of "boys" from the north and east, and it is possible that for a time the rate of wages may be materially lower than before the war. That this will be permanently so, however, is more than doubtful. As the Rand gets into full working order the demand for labour will steadily increase, possibly with great rapidity, if much fresh ground is broken and extensive developments take place. But even if wages rise to the same height as heretofore, the conditions will be more favourable. Under the Boer *régime* an extremely detrimental system of liquor licensing was maintained, which made it virtually impossible to prevent the unfortunate "boys" from getting as much alcohol (of vile and maddening quality) as they could pay for. If a mining company took every precaution with respect to their own land and premises, they were powerless to prevent the establishment of liquor shops immediately outside their holding. Normally a large portion of the native staff of the Transvaal mines were constantly incapacitated for work owing to drunkenness. The actual time lost was not the end of the trouble. When an African is drunk, and drunk on raw spirit, he is a madman with a homicidal mania. The prevalence of such where strenuous work has to be carried on is not only inconvenient, but incidentally expensive. It is to be hoped that the old scenes of chronic debauchery will be conspicuously absent in the future. If this desirable reform is effected, the working expenses of mining will be considerably reduced, irrespective of the rate of wages.

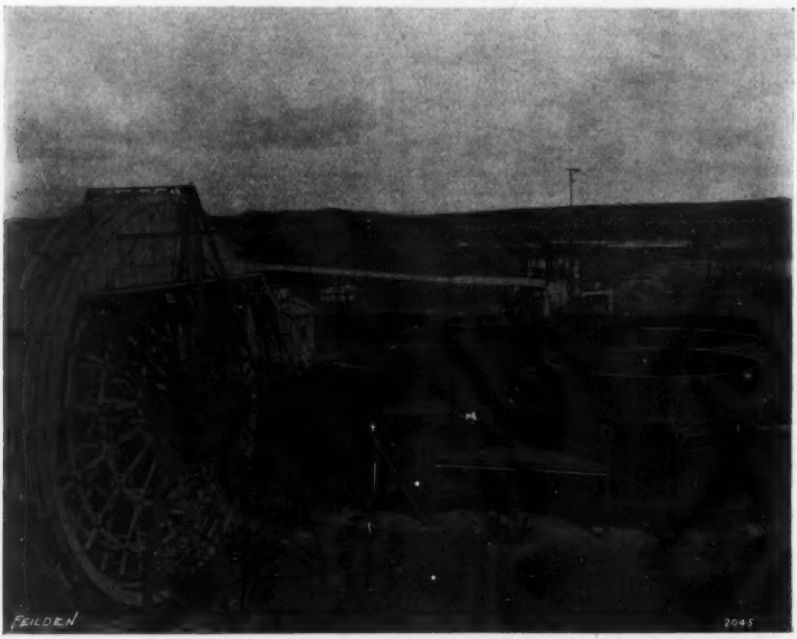
Taking for granted there will be no recrudescence of political trouble, the flow of capital into the country will assuredly be immense. As gold-mining is resumed and extended, all the cognate industries and trades will flourish, and the circulation of money on a large scale will give new and vigorous life to the community. British enterprise will at last have fair play in a country which is rich beyond all other regions of Africa—rich not only in gold, but in other metals, while its coal beds will, in the future, give the necessary power for illimitable work and progress. The soil also is the best in South Africa, and the country contains all the elementary conditions required for the growth and development of a vast civilised community, even a great nation. Such is the land which has been—blunderingly, it is true, and with more absence of mind than was wise—added to the British Empire. When the time comes for the historian possessing the necessary perspective to rightly appraise the importance and significance of this Anglo-Boer war, maybe he will decide that the most momentous and interesting feature of it was the demonstration of the real vital unity of the British people the world round. Meanwhile we have the concrete fact before us, that a new and, it is to be hoped, happier chapter is opening for the mining industry of the Transvaal.

GEOLOGY.

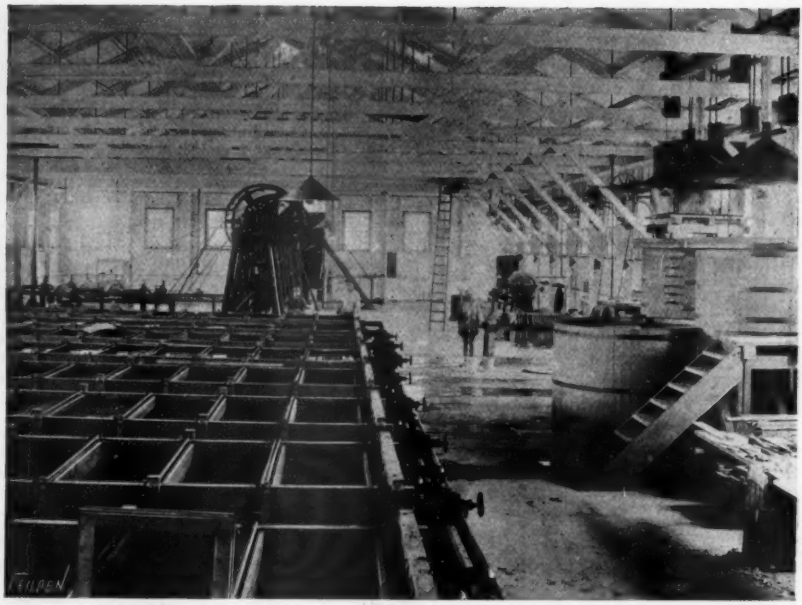
In common with many other things African, the geological features of the Transvaal cannot be judged by a European standard. An initial difficulty is the almost entire absence of fossils. Consequently the evidence is wanting which might help to a classification of the sedimentary rocks. Without entering into the vexed question of nomenclature—whether the clay shales should be called Lydenburg shales or Namaqualand schists, for instance—we will take a general view of the rocks which have been clearly identified.

Alluvial deposits include a varied collection of rocks which have accumulated on the surface, and which are sometimes of great thickness. They consist chiefly of peat, sand, recent clays, and drift—all of a quartzose nature, and carrying much iron in the form of pyrites, magnetite, red oxide, and limonite. Then the coal formation is the uppermost of the geological series next to the alluvial. It consists of silicious sandstone intercalated with clays, shales, and local beds of coal. Stratified sandstones and

quartzites underlie the coal formation, except where they are exposed at the surface (which happens over considerable areas), and the quartzites, varying in thickness indefinitely, are occasionally auriferous. These beds are usually horizontal, but in places are very much tilted, the famous reefs of the Witwatersrand being the most conspicuous example. They are also observable in the Drakensberg mountains, where they sometimes form caps to the peaks with rugged and picturesque outline. This, then, is the general formation exhibited by the country, and to the mining engineer the features alluded to are a sufficient basis for an intelligent appreciation of the possibilities of the land. Each goldfield, however, presents features peculiar to itself, and a few words on the local characteristics will suffice for our present purpose. Looking at the results, it is hardly necessary to remark that the Witwatersrand district is by far the most important gold-mining centre in the country. The "rand," or ridge, is a range of low hills some 35 miles to the south of Pretoria. On the southern slope of these hills lies the town of Johannesburg. But the goldfield may be taken to include the country immediately around Pretoria—Heidelburg, Potchefstroom, and Klerksdorp. The average height of this portion of the Transvaal is about 6,000 ft. above the level of the sea. The surface is, for the most part, flat or gently undulating, scored in a few places by rocky hills, where the intrusive rocks break up the strata. There are no trees except those which have been planted; but during the rainy season there is a rank growth of grass, which disappears with the cold winds and frosts of winter. It is the conglomerate rocks forming the reefs which naturally claim our attention particularly. It may be assumed that



CYANIDE TANKS AT THE FERREIRA DEEP MINE.



INTERIOR OF EXTRACTOR HOUSE: LANGLAAGTE DEEP MINE.

they have been deposited by currents of effluent water and that they were originally laid down in beds of pebbles alternating with sand and clay. The upheaval and dislocation of these strata, caused by repeated irruption of the trappean rocks, together with movements of the granitic base, probably brought and left these strata very much in the position in which they now are. The subsequent removal of the overlying strata, and the cutting away of the surface over a long period, has resulted in the edges of these conglomerates being exposed in places and forming the outcrops of the reefs.

As to the famous "main reef" of the Rand, and its connected leaders, they are the upturned edges of some of the most compact of these conglomerate beds, which in this instance can be traced east and west for many miles. According to Mr. C. J. Alford, F.G.S., these reefs form a series varying from 10 to 200 ft. in thickness, composed of several beds of conglomerate varying in number, separated from each other by a sandstone quartzite, white to red in colour in the upper and oxidised zones, and white to blue deeper, carrying in some places traces of granitic clay, mica, and talc, but usually free from the presence of any accessory minerals. What is known as the South Reef varies from about six inches to three feet. It is in places exceedingly rich in gold, sometimes assaying 12 ozs. to the ton. North of this is Middle Reef, varying from two feet downwards in thickness and also occasionally very rich. Further north still is the Main Reef Leader, also running from about six inches to two feet in thickness. This reef is the one from which the most magnificent general results have been obtained. Though narrow, it is persistent, and assays up to 8 ozs. per ton. Running more or less parallel to this, on the north side, is the Great Main Reef—a vast deposit from four up to 40 ft. thick. This is comparatively of poor quality, and

carries from a trace up to about one oz. to the ton, so far as it has been explored. Opinions vary as to the future of this reef. Some hold that with slightly better labour conditions than those which prevailed under the Kruger *régime* it would immediately pay to take it in hand. The writer, in a conversation with Mr. Hosken of Johannesburg, sometime Chairman of the Johannesburg Chamber of Commerce and a mining statistician well known in South Africa, questioned the value of the Main Reef as compared with the others. "These narrow reefs," said Mr. Hosken, "have been taken in hand first for the reason that, owing to the expense of working—the high rate of wages and the high price of materials and commodities, and the oppressive taxation—it does not pay to mine the Main Reef. . . . When there is something like decent government it will be quite feasible to work on the Main Reef at a profit."

Turning to the De Kaap or Barberton district, in the south-east of the Transvaal, one finds a shallow, basin-like valley surrounded by steep mountains, the Drakensberg lying on the west. Geologically, the character is analogous to the other goldfields. The base is a coarse-grained granite, sometimes passing into syenite and pegmatite. Where exposed, the granite is disintegrated to some depth and the *débris* scattered and redeposited. Overlying the granite is a series of mudstones, shales, and laminated clays, with compact quartzites. These beds, very unevenly denuded, form the mountain range of the Makongwa, to the south of Barberton. The quartzite can be traced for many miles along the range. It is generally auriferous, and sometimes payably so. On the west side of the valley the formation is very similar to the Witwatersrand field, but not so rich in gold.

In the Zoutpansburg district, low-lying

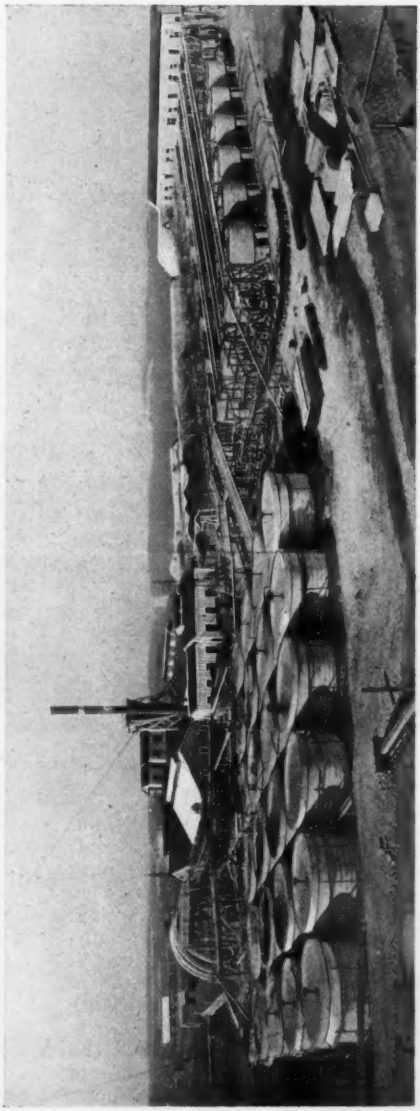
INTERIOR OF BATTERY: THE SIMMER AND JACK PROPRIETARY MINES, LTD.

land on the north, but close to the Drakensberg, there is a spur of the mountains, not so high as the range in general, which appears to be mainly composed of the quartzites, clay shales, and mudstones common to the De Kaap field, and deposited under similar conditions. In thus giving a skeleton description of the Transvaal rocks it is scarcely necessary to say that it is subject to considerable modifications locally and to further explorations in the less known regions.

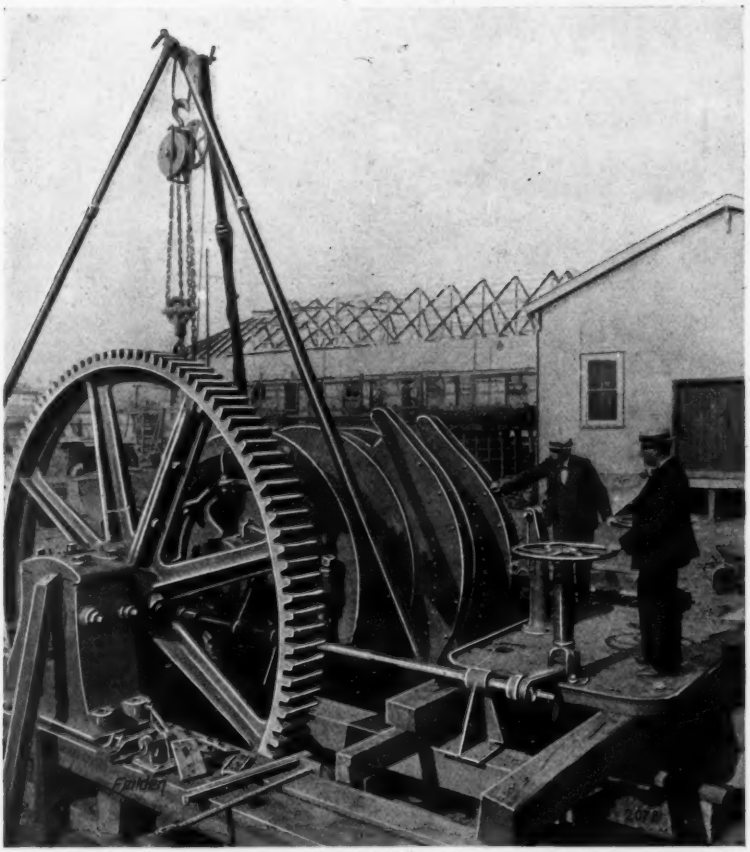
EAST RAND PROPRIETARY MINES.

Without professing to deal with anything like all of even the important mines I will now give some account of a few typical ones, not necessarily the largest, and touch briefly on such of the others as seem to demand attention. One of the aristocrats of the Rand, the East Rand Proprietary Mines, is the virile parent of a goodly litter of young companies. The record of its doings and its adventures, taken in detail and written without too close a regard to prosaic business formula, would be interesting enough. But so far as its working career is concerned, the story has at present to be cut off abruptly in the autumn of last year. In describing, or it might be more correct to say referring to, the assets of this concern, it is necessary to qualify everything with the reservation that these things were in being a year ago. What they are now neither the London staff nor the writer have any means of discovering with precision. Possibly, when the Pax Britannica has settled down upon the land, the company's agents may be able to appraise the damage.

On the assumption, however, that no very sensational events have taken place at the mine during the time these notes are going through the press, it may be well to call to mind that the last advices show that development was being proceeded with on the so-called South Reef, but nowhere else. The value of the ore exposed on the first level was exceptionally



CYANIDE WORKS: THE SIMMER AND JACK PROPRIETARY MINES LTD



300-H.P. UNDERGROUND ELECTRIC HOIST: ROBINSON DEEP, LTD.

high, particularly on the western portion of the ground. But a drive thence to about the middle of the property was not very encouraging, as the quality of the stone fell off and became very irregular. A winze sunk from the drive did not disclose anything better, neither did a cross-cut and a second winze in a southerly direction. Nothing further, it may be assumed, has been done in the development line, at least in that portion of the property. The quantity of machinery on the premises of the parent company and in possession of the subsidiary concerns is so great and complicated that anything approaching to a full description is quite impracticable. Also, as a good deal of it may be hopelessly out of repair, even if not damaged, it would be scarcely worth while to enter into details.

CONSOLIDATED MAIN REEF.

With a capital of £600,000 the Consolidated Main Reef Mines and Estate Company is one of the prominent concerns which not only mines its own

property but puts other companies on to their feet equipped with land, machinery, and working capital. Its own operations on the Main Reef are referred to at some length in a report which deals with 1899 up to the commencement of the war. The property is spoken of in three sections—the Western, Eastern, and the Central. In the Western section development work had been pushed on satisfactorily, and it was estimated that 109,950 tons of payable ore was in sight, having an average value of 10·7 dwts. per ton. It appears, however, that both development and ore extraction had been much hampered by the forced use of the old incline shaft sunk some years ago on the section. Meanwhile the work of sinking a new shaft was proceeding. The fifth level had been arrived at with only two more levels to pass to get to the bottom of the mine, and the erection of head-gear and hoisting-engine was nearly completed. Pumping had been subject to many difficulties, as the old Cornish pump in use had proved insufficient, and auxiliary steam and air pumps had to be employed. The consulting engineer was, last August, looking forward to the installation of a new electric pumping plant, which I hope has escaped the ravages of war. The average yield on that portion of the property for the year from a 40-stamp mill had been 9·53 dwts. of fine gold per ton, and the total profit £37,000 odd. On the Eastern section 5,500 ft. of development had been accomplished, of which 268 ft. were sunk in the main incline shaft, the result being considered satisfactory. Upon the whole there was over 90,000 tons of payable ore developed in the Eastern section during the year ending August. The erection of a new 40-stamp mill was spoken of as unquestionably much the most economical manner of proceeding, although the

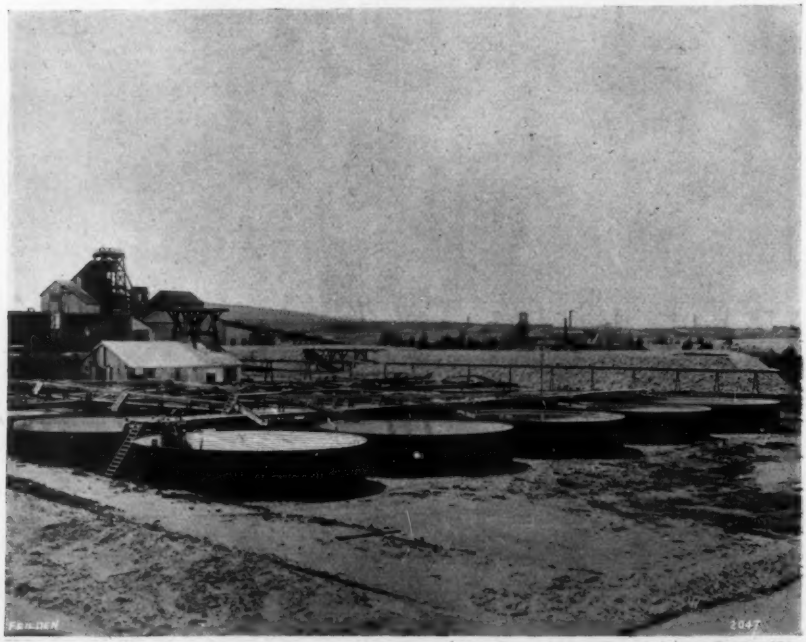
INCLINE HEADGEAR: ROBINSON GOLD-MINING COMPANY.

engineer regrets that the Central section was not likely to be developed in time to fully supply those 40 stamps when ready. The engineer said he was satisfied the profits would be proportionately increased when the additional stamps and better equipment were in working order. These anticipations of last autumn are really quite pathetic in the light of subsequent events.

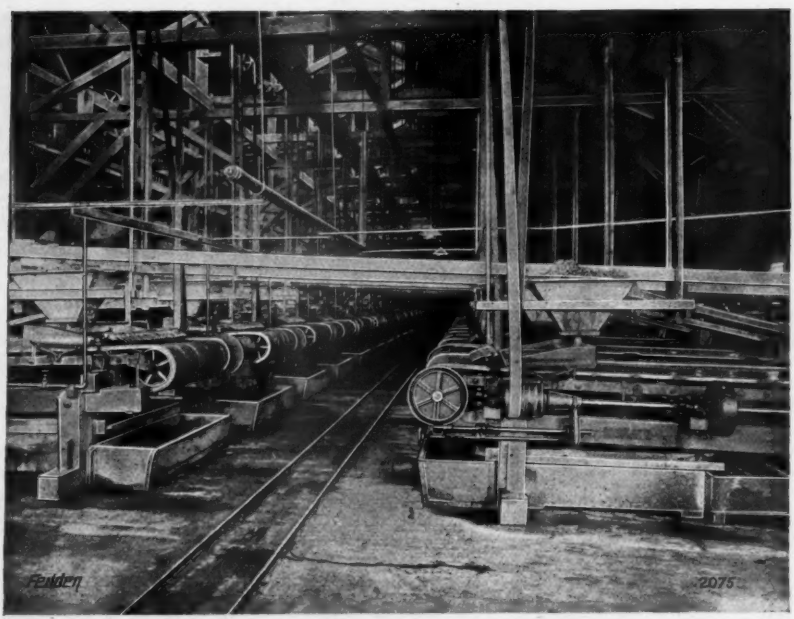
THE RAND MINES.

The Rand Mines, Ltd., is certainly one of the most important of the Transvaal gold-mining companies. It has an issued capital of £448,989, and has equipped a number of prosperous mines holding some of the richest claims on the Witwatersrand field, the names of several of them being household words, not only among speculators and brokers, but among business men throughout the mining world. There are, for instance, the Crown Deep (which I deal with separately) and the Geldenhuis Deep. The Rand Mine is also interested in the Simmer and Jack West, the Howard shaft of which is sunk to no less than 3,408 ft. At present there is only development work to record, but the mine is supposed among those best able to judge to have a great future. Then there is the Village Deep. There there are two vertical shafts of about 1,200 and 700 ft. respectively, which are expected to cut the reefs at a depth of about 2,250 ft.

A still more important and very successful mine connected with the Company is the Village Main Reef. Particulars are not to hand of the machinery employed here, and at the present juncture are unobtainable. Excellent results have been obtained, and for the half-year ending June, 1899, a dividend of 40 per cent. was paid. Again, there is the Robinson Central Deep, where a vertical shaft of



SLIMES PLANT: GELDENHUIS DEEP MINE.



WEST SIDE OF 200-STAMP MILL—50 FRUE VANNERS: THE LANGLAAGTE ESTATE AND GOLD-MINING CO., LTD.

550 ft. will be sunk to some 1,600 ft., where the South Reef will be probably encountered. The equipment of the mine is on a 100-stamp basis.

Concerning the Langlaagte Deep, the following particulars of the operations during five months of last summer may not be uninteresting. The tonnage mined during that period was 87,145 tons, and 5,800 tons were taken from the surface dumps, making in all 92,645 tons, of which 73,000 odd were milled. The yield from this tonnage was £120,734, working out at about 33*s.* per ton. The working expenditure came to 28*s.* per ton, leaving a profit of 5*s.* per ton on the ore milled. The manager does not consider that this result can be taken as a criterion of the future, as there had not been sufficient time for a knowledge of the mine itself to be gained nor for economical arrangements to be organised. In the interim report—the last report issued — dated December, 1899, the directors express themselves so well satisfied with the results, considering the short period during which the Company has been milling, that they are considering the desirability of adding a further 20 stamps, in order to bring the stamping power up to 120 stamps.

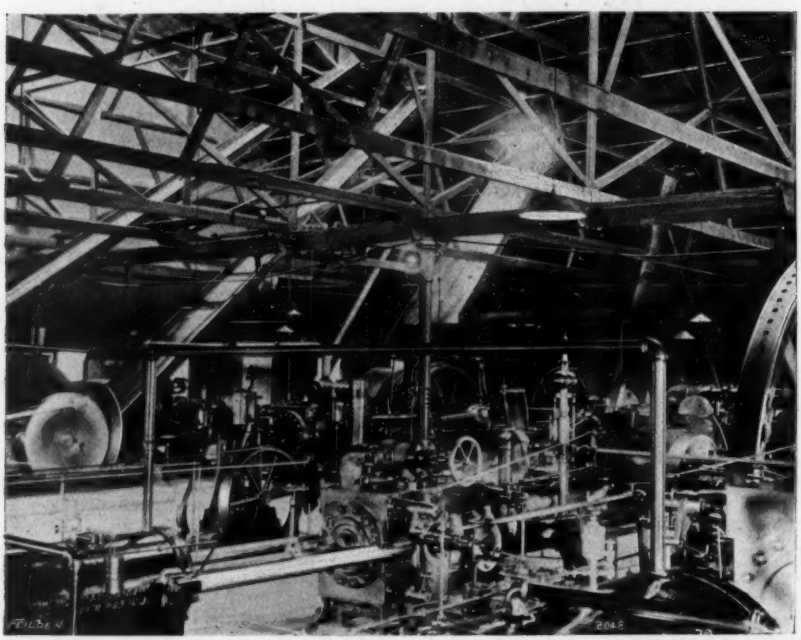
THE CROWN DEEP.

As it would be profitless to include anything like a detailed description of the machinery of even the principal gold mines, owing to the repetition which would be necessary, I will take one or two typical up-to-date plants, from which a fairly complete idea may be arrived at of the character of the installations. Conspicuous among the gigantic concerns exploiting the Rand is the Rand Mines Company, and prominent among the several subsidiary mining companies connected therewith is the Crown Deep. All that money and experience could effect was utilised to make the equipment of

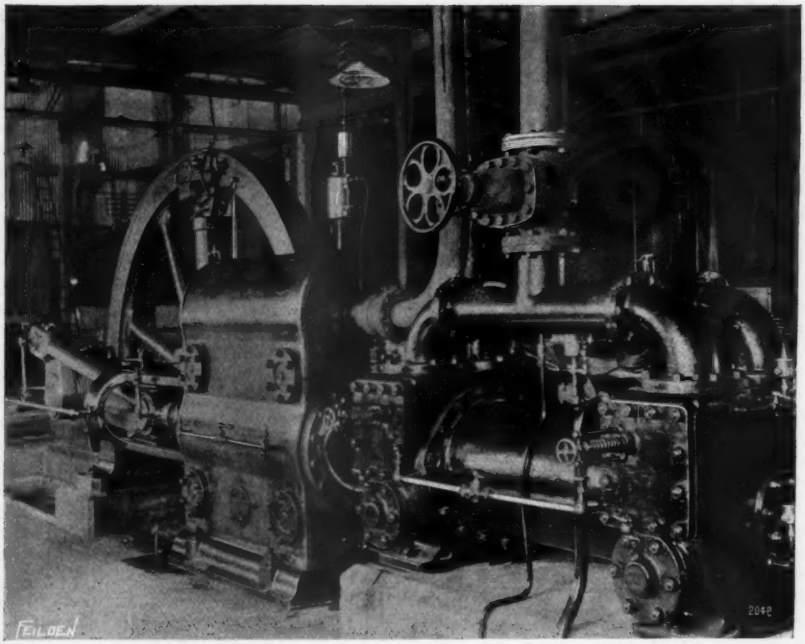
this typical mine thoroughly efficient. Others may be as good, but probably none are better. It may, therefore, be well to give the following somewhat detailed account of the machinery and plant of the Crown Deep as it was just before the outbreak of hostilities. The particulars are not official, but from a reliable source.

All the surface arrangements are conducive to easy and economical working. No. 1 shaft is connected with the rock-house by a straight, double-track tram-line, passing close to No. 2 shaft, and cars from the latter are switched on to the tram line over a short siding, so that the one main track is the only one needed. A mechanical haulage, worked from the rock-house, furnishes the power required on the tram-line, and also runs the cars up the incline to the top of the house. About half the rock broken in the mine comes out as "fines," and the cars conveying this material are dumped into shoots, which spread the fines equally over the large bin into which the coarser rock from the crushers also goes. Large rock is dumped into a shoot which leads it into a heavy trommel screen, where the rock is thoroughly washed before it falls out on to the sorting table. A strong force of water, and the rapid revolving combined, give a thoroughly clean rock for picking, and facilitate the task of the boys. The sorting table is of similar design to the others at work on the deep level propositions controlled by the Rand Mines, and is 26 ft. in diameter.

After the picking is done, the rock is ploughed off into the shoots leading to the crushers by a plough fitting close to the surface of the table. Any large pieces of sandstone with banket adhering are lifted off the table and broken up by hand, so as to separate as much sandstone as possible from the milling rock. It is pro-



NO. 1 HAULING-ENGINE AND COMPRESSOR HOUSE: JUMPER'S DEEP MINE.



HORIZONTAL RIEDLER COMPRESSOR: CITY AND SUBURBAN MINE.

bable that eventually double sorting and crushing will be resorted to, and the advantages of the system are amply demonstrated by the one or two examples of double picking and crushing to be seen on the Rand. With the crusher doing the first breaking set coarse, not much fines are made, but a large quantity of small pieces of sandstone adhering to the banket are broken off, and can easily be rejected on the second table with anything like an efficient sorting staff. Three Comet crushers are used, and can do all the breaking wanted with ease. At the bottom of the house large bins for milling rock and also for waste are provided, and the haulage up the incline to the mill bins from the rock-house bins is done by mechanical haulage driven off the mill shafting.

A good deal of water is provided for washing the rock and the slush, after the washing is run into a tank outside the house to settle prior to going to the mill. The whole of the machinery at the crusher-house is run off a line of shafting from the mill engine-room. The mill-engine is a vertical one, made by Musgrave, with 24 in. and 48 in. cylinders and 4 ft. stroke, running up to 1000 h.p. An auxiliary Fraser & Chalmers' 800 h.p. engine, with a 28 in. cylinder and 4½ ft. stroke, is provided in case anything happens to the main engine. Two compressors are also now running, a King-Riedler vertical 25-drill machine, with 24 in. high pressure and 36 in. low pressure cylinders, and a 30-drill horizontal Riedler, with 23 in. and 38 in. steam cylinders, and 23 in. and 36 in. air cylinders, and 4 ft. stroke. The mill engine, in addition to running the mill, operates the tailings wheel, the extractor house, pumping, slimes agitators, return water pumps, haulage from the mill, crusher-house plant, etc. At the cyanide

works the necessary additions to the plant are now about complete, while the top row of tanks is being considerably heightened to increase their capacity. Slimes treatment was about to be started just before the war. The tanks for it were about complete, and the large spitzkasten for settling the slimes was in hand. Agitation in the tanks is done by means of long arms of irregular length, operated from a line of shafting with worm screws for moving the agitation. Electrical boxes for treating slime solutions were in, and the lead charges prepared, while a number of tanks for holding the solutions were added. The slime is of fairly high value, and with it producing gold it is not expected that the yield will fall off much with the full mill running.

At the shafts the permanent winding engines of Fraser & Chalmers' make, with 16 in. cylinders and 4 ft. stroke, double drum and flatropes, are working satisfactorily. In addition to these there is a single drum Fraser & Chalmers' 20 in. by 48 in. direct acting engine at each shaft working on a rope. An 8 in. Cornish pump is also put down each shaft, and raises the water in five lifts in each shaft. These pumps are using about 48 h.p. each in the five lifts. They are driven by Fraser & Chalmers' engines. The return water pumps in the extractor house are each three-throw plungers, with plungers 16 ins. in diameter, 18 ins. stroke, and running at about 36 revolutions. At this speed each of the two pumps is equal to lifting 80,000 gals. an hour. In No. 1 shaft, at the third level, a Fowler's compound winding engine, driven by compressed air, hauls rock up the incline part of the shaft and tips it into the large 400 ton box, from which the skips running in the vertical part of the shaft are fed. This engine, using air equal to two drill requirements, works with 3½ ton skips. It has 13½ in. and 21 in. cylinders, with a 24 in. stroke, and its drums are 6 ft. in diameter, with 4 ft. faces.

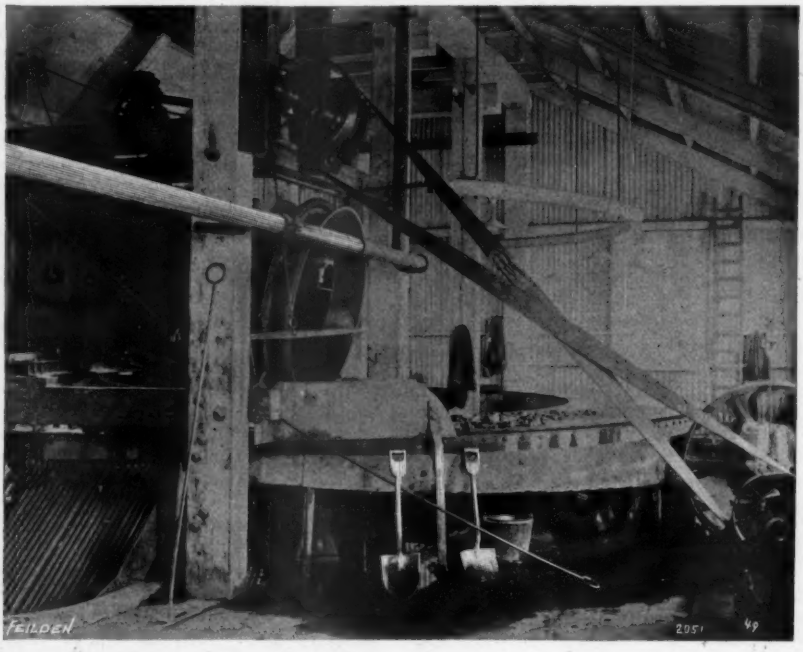
One of the great groups of mining properties demanding special attention is that associated with the Consolidated Gold Fields of South Africa, Ltd., a financial and promoting company with a capital of three-and-a-quarter millions. Foremost among the mines so connected is the gigantic concern known as the Simmer and Jack, which has the proud distinction of being the largest gold mine in South Africa. To give anything like a full description of its workings and equipment would absorb something more than the whole of my space. I propose merely to set out such information concerning the more important features, gathered from the official reports and covering 1899 up to the time of the Ultimatum or thereabouts, supplemented by information from the London office. The Company was formed in 1888 to take over certain extensive properties in the Witwatersrand field, and in 1894 additional deep-level properties were acquired, and reconstruction took place. Subsequently there was a second reconstruction, and the capital was increased to five millions sterling, of which £4,700,000 has been subscribed.

In January as many as 280 stamps were at work; and this number was kept going right up to the autumn. From the 1st January, 1898, to the 30th June, 1899, 685,010 tons of ore were crushed, yielding 326,772 ozs. of gold, worth £1,129,010. The records available come to the end of August in last year, and deal with the eleven previous months. During that period, in order to meet the heavy tonnage demanded by the mill, the ore was drawn from five shafts, viz., the East Incline, North Vertical, and Shafts Nos. 1, 2, and 3. The East Incline works a section of the property which has been cut off by a large dyke from the rest of the mine, and, in fact, forms a separate mine by itself. The ore in this section, while of low grade, proved in stoping of a better quality than shown by the levels and winzes. In the North Vertical shaft, as in the East Incline, development work is practically finished; but there is a fair prospect of one or two of the other reefs in this section being payable in places. Some development was still going on at the eighth and ninth levels.

At Nos. 1, 2, and 3 shafts, which may be called the deep shafts of the Simmer, the incline from the bottoms of all has

been pushed ahead and new levels driven in the deeper sections of the mine, in which new stopes had been opened up and were sending their quota to the mill.

In order to bring the batteries nearer to the working capacity of the different shafts, it was decided to increase the plant by 40 stamps, bringing up the total to 320. The mill engine is of sufficient power to carry this number. Additions to the cyanide plant were also in contemplation. The machinery in general was supplemented by many important items. In the cyanide works four additional steel leaching vats were put down, and four extraction boxes, besides a 30-h.p. motor and an auxiliary engine for extra haulage (1—13 in. by 22 in. by 18 in. Ide engine). At No. 1 shaft there was fitted a double-drum Webster, Camp & Lane hoist, 16 ins. by 48 ins. Other additions included :—At the No. 2 shaft, six 100-h.p. Heine boilers and smoke-stack, a single-drum Webster, Camp & Lane hoist (16 ins. by 48 ins.), a No. 6 Gates' crusher, a Greening's sorting belt, and a Calvert fuel economiser. At the No. 3 shaft, a 100-h.p. Heine boiler and a single-drum hoist, and on the ore tramway a Fairbank 60-ton weighing machine. At the No. 1 pumping station there was added a Gould's pump—triplex vertical, 12 ins. diameter by 12 ins. stroke—and a 30-h.p. motor. In the various workshops were added a M'Cabe lathe 26 ins. by 44 ins., a 10-cwt. Rigby steam hammer, and two Bradbury and one Kimber drill-sharpening machines. The construction work being carried on consisted of 40 stamps for the mill, one 75-drill Riedler air compressor, and three 300-h.p. Heine boilers.



INTERIOR OF SORTING STATION: FRENCH RAND MINE.

Another largely producing mine of the group is the Robinson Deep Gold Mining Co. The area comprises 209 claims, a tri-

angular block of 3,636 claims having been sold to the Village Deep. During the twelve-months ending with September, 1899, 7,244 ft. of underground driving, raising, and sinking were done, and 333,000 tons of ore were in sight, while 149,000 had been sent to the mill. Seventy-five stamps were running at the beginning of the period, and 100 at the end of it. There were produced from all sources 92,083 ozs. of fine gold, working out at 12·30 dwts. per ton. The average working expenses came to 31*s.* 9*d.* per ton, including 5*s.* for development redemption. Stoping had been done with machine drills, resulting in unmanageable fines and a lower grade of ore than would have been the case with hand labour. Also the cost per ton of reef stoped was raised. This necessary use of air power in stoping restricted development work, as the compressor was taxed to nearly its full capacity. Consequently an additional compressor was being put up. This stoping difficulty, which is normal all over the Rand, arises from the scarcity of native labour. This mine has been heavily handicapped by these conditions, and a good deal of delay has occurred in bringing the full number of stamps into operation. Eighty additional stamps on order were in course of erection. These, when ready, would make an aggregate of 200.

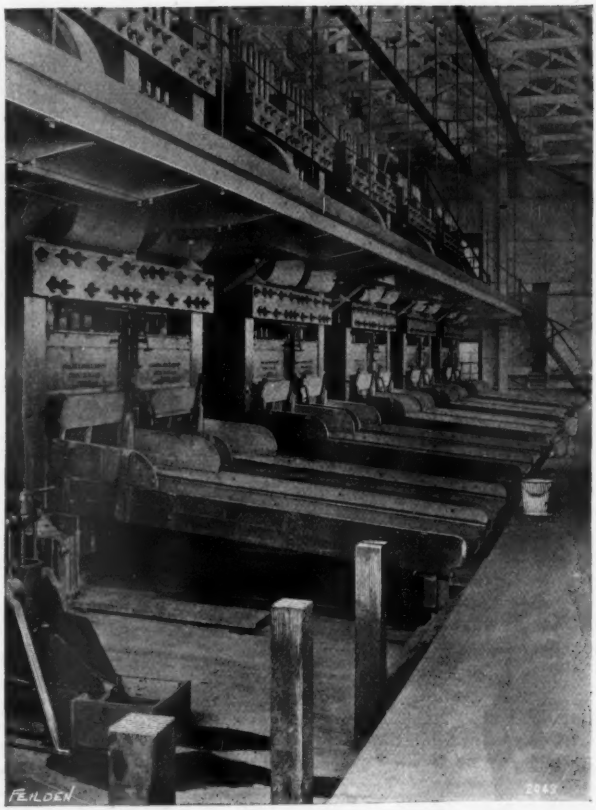
Knight's Deep is another hopeful of the "Consolidated" to be mentioned. It possesses 179 claims on the dip of the Glencairn and Witwatersrand Companies; it has two shafts, the Connor and Robertson, 2,120 ft. apart. Development work was progressing on the 1,160 ft. level of the Connor, east and west drives on the reefs showing very good results. A station has been cut at the 1,050 ft. level, and a cross-cut driven which encountered the reefs at 236 ft. north of the shaft, the Main Reef showing a thickness of 68 ins., 12 ins. of which assayed 19 dwts., the remainder being poor. Nine feet beyond the Main Reef, the North Reef was encountered, 42 ins. of which assayed 10 dwts., and another band of 12 ins. 13 dwts., while a narrow strip of 3 ins. yielded 33 dwts. At the Robertson shaft development work had been pushed on at the 1,100, 1,200, and 1,300 ft. levels. During the year about 176,000 tons of ore were developed, which was estimated to contain about 12 dwts. to the ton. Mr. Webb, the superintending engineer, anticipated that by January of this year the two shafts would be connected underground. At the surface, both shafts were thoroughly equipped.

The Simmer East Mine, included in the group, was in the development stage when the war broke out. Operations were chiefly through the Hammond shaft, and work was being carried on at all the levels. The surface equipment on this property consists of large permanent winding engines at each shaft, two 35-drill air compressors, shops, office, and living quarters. At one of the shafts, however, there was still some work to be done on the surface in completing the details of the headgear, adding to the boiler plant, and constructing the ore haulage line to the mill. Also in the preliminary stage is the South Rose Deep, possessing one shaft 2,275 ft. deep, and another over 2,300 ft. The stone exposed was broken and irregular in places, but was estimated to average about 9 dwts. to the ton. On the surface at this shaft the permanent headgear, winding engines, and air compressor are in place. It was expected that crushing operations would be commenced about December, 1901. Probably this anticipation will not be realised until twelve months later.

The South Geldenhuis Deep holds 192 claims situated on the dip of the Simmer and Jack proprietary. It has two shafts, 2,600 ft apart. The eastern, or Milner shaft, had reached 2,739 ft. The records of the Rand Victoria borehole, 180 ft. north, give the depth at which the lower or main reef was encountered at 2,397 ft.; but the formation in the lowest section of this shaft was found to dip at an angle of about 45 degs.—considerably steeper than the average hitherto calculated in estimating depths to the reef in deep-level mines on the Rand. Sinking was, however, proceeding, and there is little doubt of the reef being struck eventually. A new large winding engine was on order for this shaft, and timber for headgear was

being delivered. The Rhodes, or western shaft, has reached 1,892 ft., the estimated necessary depth being 2,500 ft. Here, again, a very steep formation has been found, with a dip of about 50 degs., so that the depth of the reef at this point may be very great. Anyway, the shaft will have to be sunk deeper than was expected. The plant on the surface is temporary, but a permanent equipment is on order.

A somewhat similar story has to be told of the Simmer and Jack West. The property lies on the dip of the Geldenhuis Deep, and its western shaft has been sunk to 3,408 ft., although it was imagined that 2,800 ft. would take it to the reef. No thought of abandoning the work seems to have been entertained, and the surface equipment includes permanent headgear and new winding engines. Perseverance may yet be rewarded. The Jupiter Gold Mining Co. is in like case, sinking a deep shaft which it is intended to connect with the Howard shaft of the Simmer West. The Rand Victoria Mines, adjacent, hold 299 claims, but are not so advanced as their neighbours, and one shaft has only just been started. The Nigel Deep, another of the series, has an old shaft, on which work has been resumed, and is supposed to be within 450 ft. of the reef. When it is reached, the expectation is, judging from a neighbouring outcrop, that a very rich body of ore will be struck.



STAMP BATTERY: FERREIRA DEEP MINE.

Two other shafts are in work and crushing is going on, the stone yielding about 13 dwts. of fine gold per ton. The Sub-Nigel has been fortunate in arriving at good stone at 524 ft., and development is proceeding. The Central Nigel Deep, contiguous, had three shafts started, but work on two only has been pursued of late, the depths being about 1,000 ft. and 800 ft. respectively.

I have dealt seriatim with the mines of this group, as showing, on the one hand, the magnificent results to be obtained by the prudent outlay of vast capital, as in the case of the Simmer and Jack,

and, on the other, the perseverance and risks involved where, as in the case of some of the subsidiary companies, the conditions are, though hopeful, not always favourable to the rapid realisation of a dividend.

ROBINSON GROUP.

I come now to the Robinson group of mines, of which the Randfontein Estates Gold Mining Co. may be considered the parent. This corporation has a capital of £2,000,000, which has been devoted to the purchase of claims and so forth, and the "floating off" of subsidiary companies. It has not undertaken mining work direct. There are about a dozen companies emanating from the Randfontein Estates, but I will take only two as typical of the others, and as being the most important of the group—the Langlaagte Estate and Gold Mining Co. and the Porges Randfontein Gold Mining Co. The former has a capital of £470,000, and is a 200-stamp concern. An official report as to the condition of the plant and machinery does not reveal much in the way of detail, but I gather that the compressor plant has worked very satisfactorily, and that in connection with it are Babcock & Wilcox boilers, which have done good service.

The ore mined is about 300,000 tons a year, and last report records a crushing of 274,000 tons. From this was recovered 86,056 ozs., or at the rate of 6·29 cwts. per ton. The cyanide department consists of the old works and the new. The former has five circular cemented leaching vats of 450 tons capacity, and the latter 10. The tailings come out at about one ounce of gold to every seven tons, and the cost of treatment is about 1*s.* 9½*d.* per ton. Concentrates show, for 7,448 tons crushed, 20,985 ozs. of gold. Development work was proceeding from the main shaft.

As regards the Porges Randfontein, it was considered that the sinking of a new central shaft placed the mine in a much better position than it had been before, and it is anticipated that the deeper levels will consequently be worked to much greater advantage when the mine gets to work again. The crushings of this mine are verging on 100,000 tons in this year, and the yield is about 10 dwts. per ton.

Speaking generally, it may be said that the great feature of the Transvaal goldfields is the prodigious quantity of ore available, rather than any phenomenal richness of the stone. The mines I have selected as examples of the fields are typical, and their characteristics are found repeated in scores of instances. Many important and flourishing undertakings are not mentioned, for the reason that my object has been to present a general view of Transvaal gold mining, with a few examples from successful mines, rather than to furnish a schedule of such, with the reiteration of detail which would necessarily follow. In the reports from the engineers and managers which have been placed at my disposal, the question of native labour is again and again referred to, and it is impossible to avoid the conclusion that the deprivation of facilities for intoxication would not only be an immense gain to the mining companies, but a blessing to the native almost impossible to exaggerate.

G. Emerson Russell

In this section is presented every month a concise précis of the contents of the leading organs of the technical press and of the proceedings of the learned societies throughout Great Britain, the Continent, and America, and also, in a summarised form, the subject matter of the more important articles appearing therein.

This systematic record should prove of the greatest value to those of our readers interested in one or more specific sections of technology, trade or economics, or to those who have insufficient leisure to peruse the large number of publications now appearing.

The following is an Index to the abbreviations used throughout the section. It gives an alphabetically-arranged list of the publications regularly reviewed, together with the place of publication. In most cases where publications are not readily procurable, with the exception of Transactions of the learned societies, copies of the articles can be supplied on application and by remitting 7d.

Am. Engr. ...	American Engineer	New York
Am. Machy. ...	American Machinery	New York
Am. Mach. ...	American Machinist	New York
Am. Mftr. and Ir. Wld.	American Manufacturer & Iron World	Pittsburg
Am. Shipbldr.	American Shipbuilder	New York
Ann. des Pts. et Chauss.	Annales des Ponts et Chaussées	Paris
Archt.	Architect	London
Arch. Rcd. ...	Architectural Record	New York
Arch. Rev. ...	Architectural Review	Boston, U.S.A.
Arms and Exp.	Arms & Explosives...	London
Aust. Min. Stand.	Australian Mining Standard	Sydney
Autom. and Horsel. Veh. Journ.	Automotor and Horseless Vehicle Journal	London
Berg Hüttenm. Ztg.	Berg und Hüttenmannische Zeitung	Berlin
Board of Tr. Journ.	Board of Trade Journal	London
Brit. Archt. ..	British Architect ...	London
Bri. and Col. Prtr.	British & Colonial Printer	London
Bldr.	Builder...	London
Bldrs'. Journ.	Builders' Journal ...	London
Bull. d. l. Soc. d'Encour.	Bulletin de la Société d'Encouragement	Paris
Canad. Elec. News	Canadian Electrical News	Toronto
Canad. Engr. ...	Canadian Engineer	Montreal
Can. Mftr. ...	Canadian Manufacturer	Toronto
Canad. Min. Rev.	Canadian Mining Review	Ottawa
Carr. Bldrs'. Journ.	Carriage Builders' Journal	London
Cassr. Mag. ...	Cassier's Magazine	New York & London.
Chamb. of Com. Journ.	Chamber of Commerce Journal	London
Chem. Trds. Journ.	Chemical Trades Journal	Manchester
CoachBldrs'.Art Journ.	Coach Builders' Art Journal	London
Cold Storage ...	Cold Storage ...	London
Coll. Guard. ...	Colliery Guardian ...	London
Comm. Int. ...	Commerce Intelligence	London
Compt. Rend. ...	Comptes Rendus de l'Acad. des Sciences	Paris
Compt. Rend. des Ing. Civ.	Compte Rendu de la Société des Ingénieurs Civils	Paris
Contr. Journ. ...	Contract Journal ..	London
Deutsch. Techn. Ztg.	Deutsche Techniker Zeitung	Berlin
Dingler's Polyt. Journ.	Dingler's Polytechnisches Journal	Stuttgart
Dipl. and Cons. Rpts.	Diplomatic & Consular Reports	London & Washington
Ech. d. Mines	Echo des Mines ...	Paris & Brussels
Ecl. Elect. ...	Eclairage Electrique	Paris
Elec. Engr. ...	Electrical Engineer	London
Elec. Engrg. ..	Electrical Engineering	Chicago
Elec. Rev., London	Electrical Review ...	London
Elec. Rev., New York	Electrical Review ...	New York
Elec. Wld. ...	Electrical World ...	New York
Electn.	Electrician	London
Electn., Paris ...	Electricien	Paris
Electrotechniker	Electrotechniker	Vienna
Electy., London	Electricity	London
Electy., New York	Electricity	New York
Elektrochem. Ztschrft.	Elektrochemische Zeitschrift	Berlin
Elektrotech. Ztschrft.	Elektrotechnische Zeitschrift	Berlin
Elettricita ...	Elettricita	Milan
Engr.	Engineer	London
Engr., Cleveland	Engineer	Cleveland, U.S.A.
Engrg.	Engineering ...	London
Engrg. and Min. Jour.	Engineering and Mining Journal	New York
Engrg. Mag. ...	Engineering Magazine	New York & London
Engrg. News ...	Engineering News ...	New York
Engrg. Rcd. ...	Engineering Record	New York
Engl. Mech. ...	English Mechanic ...	London & New York
Gas Wld. ...	Gas World	London
Gaz	Gaz, Le...	Paris
Gén. Civ. ...	Génie Civil	Paris
Ges. Ing. ...	Gesundheits-Ingenieur	Munich
Glaser's Ann. ..	Glaser's Ann. f. Gewerbe und Bauwesen	Berlin
Hrdw., Mets. and Machy.	Hardware, Metals & Machinery	London
Hrdw. Trds. Journ.	Hardware Trades Journal	London
Heatng. and Ventng.	Heating & Ventilating	New York
Hosiery Tr. Jr.	Hosiery Trade Journal	Leicester

Ice and Cld. Storge.	Ice & Cold Storage	London
Ill. Off. Journ. of Pat.	Illustrated Official Journal of Patents	London
Ind. and East Engr.	Indian & Eastern Engineer	Calcutta
Ind. Engrg.	Indian Engineering	Calcutta
Ind. Elec. Chim.	Industrie Electro Chimique	Paris
Ingrm.	Ingenorum	Copenhagen
	Irish Textile Journal	Belfast
Ir. Age.	Iron Age	New York
Ir. and Coal Trds. Review	Iron and Coal Trades Review	London
Ir. and Steel Trds. Journ.	Iron & Steel Trades Journal	London
Ironmgr. ...	Ironmonger	London
Ir. Ass. Eng. Socs.	Journal of the Association of Engineering Societies	Philadelphia
Jrn. Chem. Soc.	Journal of the Chemical Society	London
Journ. of Comm.	Journal of Commerce	Melbourne
Journ. of Elec.	Journal of Electricity	San Francisco
Journ. of Electr. Power and Gas	Journal of Electricity Power and Gas	San Francisco
Journ. of Gas Lghtng.	Journal of Gas Lighting	London
	Journal Inst. Elec. Engrs.	
Journ. of Roy. Inst. of Br. Archts.	Journal of Royal Inst. of British Architects	London
Journ. of State Med.	Journal of State Medicine	London
Journ. of Soc. of Arts	Journal of the Society of Arts	London
Knowl.	Knowledge	London
Ldry. Journ. ...	Laundry Journal ...	London
Ldry. Rec. ...	Laundry Record ...	London
Lghtng.	Lightning	London
Lt. Ry. & Tramw. Jr.	Light Railway and Tramway Journal	London
Locom. Engrg.	Locomotive Engineering	New York
Loc. Mag. ...	Locomotive Magazine	London
Machinery, London	Machinery	London
Machinery, New York.	Machinery	New York
Mach. Mark. ...	Machinery Market ...	London
Mftrr.	Manufacturer ...	Philadelphia
Mar. Engr. ...	Marine Engineer ...	London
Mar. Engrg. ...	Marine Engineering	New York
Mech. Engr. ...	Mechanical Engineer	Manchester
Mech. Prog. ...	Mechanical Progress	M'chr.
Mech. Wrld. ...	Mechanical World ...	London
Metall.	Metallurgie	Paris
Miller	Miller	London
Mns. & Mnrls.	Mines and Minerals	Denver
Min. Journ. ...	Mining Journal ...	London
Ming. Wld. ...	Mining World ...	London
Mitt. a. d. Kgl. Tech. Versuchsanst, Berlin	Mitt. aus d. Kgl. Tech. Versuchsanst	Berlin
Mod. Machy. ...	Modern Machinery...	Chicago
Mois Scient. ...	Mois Scientifique ...	Paris
Motor Cr. Jr. ...	Motor Car Journal...	London
Nat. Ldry. Journ.	National Laundry Journal	Chicago
Nature	Nature	London
Nature, Paris ...	Nature	Paris
Naut. Gaz. ...	Nautical Gazette ...	New York
N. B. Agrilt. ...	North British Agriculturist	Edinburgh
Oest. Monatsschr. f. d. Oeff. Baudienst	Oest. Monatsschr. f. d. Oeff. Baudienst	Vienna
Oest. Zeitschr. f. Berg u. Hüttenwesen	Oest. Zeitschr. f. Berg und Hüttenwesen	Vienna
Power	Power	New York
Pract. Engr. ...	Practical Engineer...	London
Proced. Am. Soc. Civ. Engrs.	Proceedings, Am. Soc. of Civil Engineers	New York
Proced. Engrs. Club	Proceedings of the Engineers' Club of Philadelphia	Philadelphia
Pub. Hlth. Engr.	Public Health Engineer	London
Rld. Gaz. ...	Railroad Gazette ...	New York
Ry. Age ...	Railway Age	Chicago
Rail. Engr. ...	Railway Engineer ...	London
Rail. and Engng. Rev.	Railway & Engineering Review	Chicago
Rail. Mag. ...	Railway Magazine ...	London
Railw. Mast. Mech.	Railway Master Mechanic	Chicago
Rail. News ...	Railway News ...	London
Rail. Rcd. ..	Railway Record ...	London
Ry. Sup. Jr. ...	Railway Supplies Journal	London
Rev. Min. ...	Revista Minera ...	Madrid
Rev. Tech. ...	Revue Technique ...	Paris
Rev. d. Chim. Ind. ...	Revue de Chimie Industrielle	Paris
Sch. Mines Qtly.	School of Mines Quarterly	New York
Science Abstr. ...	Science Abstracts ...	London & New York
Sci. Am. ...	Scientific American	New York
Sci. Am. Suppl.	Scientific American Supplement	New York
Shpng. Wrld.	Shipping World ...	London
South Afr. ...	South Africa... ...	London
Stahl u. Eisen. ..	Stahl und Eisen ...	Dusseldorf
Steamsh. ...	Steamship	Leith
Stevens' Inst. Ind.	Stevens' Institute Indicator	New York
Stone	Stone	New York
St. Ry. Inter. Jr.	Street Railway International Journal	New York
Survr.	Surveyor	London
Syr.	Syren	London
Tech. Qtly. ...	Technology Quarterly	Boston
Text. Ind. ...	Textile Industries ..	Bradford
Text. Merc. ...	Textile Mercury ...	Manchester
Text. Rcdr. ...	Textile Recorder ...	Manchester
Text. Ztg. ...	Textil-Zeitung ..	Berlin
Tramw. and Railw. Wld.	Tramway & Railway World	London
Trs. Am. Soc. M. E.	Transactions of the American Society of Mechanical Engineers	Cincinnati
Trs. Inst. Nav. Arch.	Transactions of the Inst. of Naval Architects	London
	Trans. Inst. Engrs. & Shipbuilders	Glasgow
Trs. N. E. Inst. Engrs. and Shpbldrs.	Transactions of the N. E. Coast Institution of Engineers and Shipbuilding	Newcastle
	Trans. Soc. Engrs.	
Un. Ser. Mag.	United Service Magazine	London
West. Electn. ...	Western Electrician	Chicago
Ztschrft. d. Oest. Ing. u. Arch. Ver.	Zeitschr. d. Oest. Ing. u. Arch. Vdr.	Vienna
Ztschrft. d. Ver. Deutsch. Ing.	Zeitschr. d. Ver. Deutscher Ingen.	Berlin
Ztschrft. f. Elektrochem.	Zeitschrift für Elektrochemie	Halle a. S.
Ztschrft. Elektrotech.	Zeitschrift für Elektrotechnik	Halle a. S.

ARCHITECTURE AND BUILDING.

1. Construction and Design.

Cathedrals.—*Some Westphalian Cathedrals and Churches. VI.* By T. Francis Bumpas. The present instalment deals with the mediæval cathedrals of Herford and Minden, situated within one of the most picturesque districts of Westphalia. 2¾ cols.—*Brit. Archt.*, Sept. 21st, 1900.

Expanded Metal.—*The Use of Expanded Metal in Concrete.* Abstract of a paper read on Sept. 7th, by Mr. A. T. Walmisley, M.Inst.C.E., before the British Association at Bradford. The article deals with the subject of the judicious introduction of iron and steel sections as a tensile element in the construction of concrete beams and slabs. 10½ cols.—*Bldr.*, Sept. 15th, 1900.

Stone Staircases.—*Stone Staircase Construction. II. Circular Stairs.* By W. & A. Mowat. The author in this article deals with some of the technical difficulties connected with the "setting out" and forming of the steps. (Ill.) 4 cols.—*Stone Trds. Journ.*, Sept. 1900.

2. Heating and Ventilation.

Heating and Ventilating.—*Warming and Ventilating of the Theatre Royal, Manchester.* Description of the plant laid down by the Sutcliffe Ventilating and Drying Company, with the following objects in view: (1) To make use of every then existing air-shaft that could in any way be adapted to the purpose. (2) To cut the building about as little as possible. (3) To create a slight plenum or pressure inside the theatre, so that the air had a tendency to pass through the crevices of the doors, etc., from the inside to the outside. (4) To leave no room for complaint by the fire insurance authorities. ⅔ col.—*Brit. Archt.*, Sept. 21st, 1900.

3. Plumbing and Gas Fitting.

Plumbing.—*Plumbing in a large City House.* Description of very complete and very practical work done in a residence in New York City. 1½ col.—*Eng. Rcd.*, July 28th, 1900

4. Miscellaneous.

Architectural Training.—*Architectural Education in the United States.* By Arthur Cates. Abstract of a paper published in the R.I.B.A. *Journal*, in which the author dwells on the great progress made in the development of architecture in the United States, whose present generation received their education in Paris, and which has meanwhile furnished able professors to local universities, which give equal, if not greater facilities to students than the institutions in the French capital, and may, perhaps, in time attract even British students of architecture to America. 4⅓ cols.—*Brit. Archt.*, Aug. 31st. 1900.

Architecture.—*Two Chapters on Colonial Architecture.* The article is mainly a review and digest of a volume entitled "Early Connecticut Houses." An historical and architectural study. By Norman M. Isham, A.M., architect, and Albert R. Brown, architect, Providence, R.I. The Preston and Rounds Company, 1900. (Ill.) 5 cols.—*Bldr.*, Sept. 22nd, 1900.

Building Material.—*The Testing of Portland Cement.* Instructive article describing the most practical methods and appliances for testing this important building material, consisting for the most part of aluminates and silicate of lime resulting from the calcination of materials containing clay and lime. 7½ cols.—*Mech. Engr.*, Sept. 15th, 1900.

Durability of Stones.—*The Durability of Monumental and Building Stone.* The article deals with the durability of stone and the causes of decay, referring to a contribution in the *Monumental News*, containing many suggestions interesting to both the carrier and the dealer, and to a volume recently published by the State of Wisconsin, dealing with its ornamental and building stones. 1¾ cols.—*Stone Trds. Journ.*, Sept., 1900.

Slate Quarries.—*Société de la Commission des Ardoisières d'Angers.* By Messieurs G. Larivière et Cie., Proprietors. The authors, after a short introduction on the characteristics and useful features of "true slate," proceed to describe their own slate quarries, one of the grandest slate works in the world, in the heart of the French Department of Maine et Loire, at the junction of four lines of railway. (Ill.) 7 cols.—*Stone Trds. Journ.*, Sept., 1900.

Stone Carving.—*II. The "Orders" and their Origin.* By G. A. T. Middleton, A.R.I.B.A. This is a very interesting and attractive presentation of the origin and meaning of the "orders" of classic architecture, which have so entirely dominated all work of the Classic and Renaissance periods and have largely influenced that of many other periods. (Ill.) 2¾ cols.—*Stone Trds. Journ.*, Sept., 1900.

Timber.—*Timber at the Paris Exhibition.*—An interesting supplement dealing with the various timber exhibits, beginning with that of the United States (which, as the author points out, should have been one of the first, and for which the American Forestry Annexe had been erected at Vincennes, but which, at the time of his writing [Sept. 1st], was still quite incomplete, the most important part having not yet arrived), and describing the exhibit of India, a portion of that of Canada, of Meurisse Bros., of J. Hollande & Son, of M. Amédée Cottray, and of Leon Delpierre & Sons. To this is added a contribution dealing with exhibits in the machinery section, prominent among which is the fine display of J. & C. G. Bolinder, of Stockholm, who were awarded a Grand Prix. (Ill.) 18 cols.—*Timber Trds. Journ.*, (Supplement No. 5), Sept. 15th, 1900.

Timber Trade.—*Notes on the Swedish Timber Trade.* The author points out that some time ago the ports of Germany or South-western Russia were almost the only ones known to architects; "all red deal," so the specifications ran, "must be best Memel or best Riga," and the same words are often used to-day, although Memel red is practically a thing of the past. Meanwhile Swedish timber has come more and more to the foreground, and to the magnitude of the Swedish trade, both actual and relative, this contribution is devoted. 4½ and 7 cols. respectively.—*Bldr.*, Sept. 8th and 15th, 1900.

CIVIL ENGINEERING.

1. Bridges.

Bridges.—*German Bridge-building Exhibits at the Paris Exhibition.* The present instalment deals with the exhibit of the Gute Hoffnung Works and the pin-bridges of the Harkort Company, of Duisburg on the Rhine. (Continuation.) (Ill.) 4 cols.—*Engrg.*, Sept. 7th, 1902.

Electric Locomotives.—*Electric Locomotives in Coal Mining.* The author reviews the use of electricity in coal mines, from its employment in a few simple operations, such as signalling and blasting, to its modern extension for drilling, cutting, pumping, hoisting, hauling, and lighting. 4¾ cols.—*Engrg.*, Sept. 7th, 1900.

Bridges.—*A Hundred Years of German Bridge-building.* By Georg C. Mehrtens, translated from the German by Ludwig Mehrtens, C.E., with 195 illustrations. Berlin: Julius Springer, 1900. First notice. Review of a highly interesting publication, which owes its origin to the enterprise of six German bridge-building firms, and describes the work done by German brid ge-builders during our century, incidentally alluding also to the work of other nations. 2 cols.—*Engr.*, Sept. 21st, 1900.

Bridges.—*The Bridge Work of the Pittsburg, Bessemer, and Lake Erie and Union Railways.* The article deals with some details and features of unusual novelty in the great amount of bridge and viaduct work of these bridges, comprising in round figures the erection of 22,000 tons of steel in the form of single and double track bridges and viaducts. 6¼ cols.—*Engrg. News*, Aug. 16th, 1900.

—— *The 721-ft. Three-hinged Steel Arch Railway Bridge across the River Viaur, France.* Description of one of the most notable metal arch bridges of recent years, built to carry the railway line of Carmaux-Rodez across the valley of the River Viaur, in France. (Ill.) 7½ cols.—*Engrg. News*, Sept. 6th, 1900.

2. Canals, Rivers, and Harbours.

3. Irrigation.

4. Miscellaneous.

ELECTRICAL ENGINEERING.

1. Electro-Chemistry.

2. Electric Lighting.

Electric Lighting.—*The Nernst Lamp at the Paris Exposition.* Description of the very interesting display in the Electrical Palace at Paris of the Nernst Lamp, by the Allgemeine Elektricitäts-Gesellschaft of Berlin, consisting of two types, in the one of which it is necessary to heat the conducting filament by a match, an alcohol lamp, or the like; while the second is automatic, being lighted by an electric current, which is switched off after the filament has become incandescent. (Ill.) 2½ cols.—*Elec. Rev.*, Sept. 5th, 1900.

—— *Electricity versus Gas for Train Lighting.* By Alton D. Adams. The author, alluding to the fact that railway trains are about the last important structures, when power is available, that have not generally adopted the electric light, shows that this is not only to the disadvantage of the public, but also of the companies. 2 cols.—*West. Electn.*, Aug. 11th, 1900.

—— *The Lighting of the Coliseum.* Description of the electric lighting plant at the Chicago Coliseum in Wabash Avenue, standing on the site of the famous Libby Prison, and having a total length of 307 ft., and a width of 173 ft., with a total seating capacity of 10,000; the building is fireproof throughout, the roof consisting of concrete laid 3 in. thick. (Ill.) 2½ cols.—*West. Electn.*, Sept. 8th, 1900.

—— *Progress in Arc Lighting by Alternating Current Lamps.* By H. W. Hillman. Abstract of a paper read before the Ohio Electric Light Association at Toledo, Aug. 16th, 1900. 4½ cols.—*West. Electn.*, Sept. 1st, 1900.

—— *The Electric Lighting of the City of Glasgow.* This is a first instalment of a contribution on the subject, and, after a historical review of the beginning of the enterprise, gives a description of the Port Dundas Works. (Ill.) 3 cols.—*Elec. Engr.*, Sept. 21st, 1900.

—— *Street Lighting.* By H. H. Wait. Abstract of a paper read before the North-western Electrical Association, at Waupaca, Wis., in which the author treats on the subject of arc lighting, and considers especially the intensity of illumination at the street surface obtained with different systems. (Ill.) 3 cols.—*West. Electn.*, Aug. 4th, 1900.

—— *Incandescent Lighting as an Architectural Decoration.* The article deals with the artistic progress of recent years made in the design and manufacture of electric lighting fixtures, and describes a number of devices placed upon the market by the General Electric Company, New York. (Ill.) ¾ col.—*Elec. Rev.*, Aug. 8th, 1900.

—— *A Submarine Arc Lamp.* Description of a submarine arc lamp invented in the laboratories of Yale and giving a light of 2,000 candle-power. Former inventors attempted to accomplish this result, but failed, for they endeavoured to feed air to the lamp and to remove the gases from the arc by means of rubber tubes leading to the surface, which made the outfit too cumbersome; the new lamp is neat and light in its construction, no air-tubes being used, and the feeding of oxygen to the arc is secured by a process known only to the inventors. (Ill.) 2 cols.—*Elec. Rev.* (New York), Sept. 5th, 1900.

3. Power.

Dynamos.—*The Construction of Large Dynamos as exemplified at the Paris Exhibition.* By Silvanus P. Thomson, F.R.S. Abstract of a paper read before the British Association at Bradford, in which the author systematises the characteristic tendencies prevailing at present in the construction of dynamos on the Continent, and points out that the two-pole type of direct-current dynamo was not represented by Continental exhibitors, except for very small motors; nor was another English type to be seen, namely, the alternator with the armature built up of thin cords of bare copper. 2½ cols.—*Elec. Engr.*, Sept. 14th, 1900.

Dynamos.—*Compound Engine and Dynamo at the Paris Exhibition.* Description of a dynamo constructed by Messrs. Galloways, Ltd., and Messrs. Mather & Platt, Ltd., Manchester, the dynamo being a shunt-wound machine, with an output of 220 to 250 volts and 1,400 ampères of 105 revolutions per minute. 2½ cols.—*Mech. Engr.*, Sept. 15th, 1900.

Electrical Cranes.—*Electrical Travelling Cranes.* By Claude W. Hill. The article deals with the successive steps in the development of the electric traveller, and describes concisely single-motor cranes, multiple-motor cranes, and controllers, concluding with an account of a multiple-motor crane designed by the author. (Ill.) 2 cols.—*Elec. Rev.* (New York), Sept. 7th, 1900.

Electricity Works.—*Rathmines Municipal Electricity Works.* Description of a small but very complete electrical plant situated at Rathmines, near Dublin. (Ill.) 2½ cols.—*Engr.*, Sept. 7th, 1900.

—— *Rathmines Municipal Electricity Works.* Description of the new electricity works at Rathmines, near Dublin, inaugurated on Aug. 31st. (Ill.) 4½ cols.—*Elec. Engr.*, Sept. 14th, 1900.

Electric Power.—*Electrically Operated Steel and Iron Foundry.* Description of the electric plant at the new foundry of the Sargent Company at Chicago Heights, Ill., which has been the first in the United States to adopt throughout electric power of transmission. (Ill.) 2¾ cols.—*West. Electn.*, Aug. 25th, 1900.

—— *Electric Canal Towage.*—Editorial suggestions that electricity might profitably be employed for towing loaded vessels on the great system of inland water-ways in the United States. An excellent opportunity would, in the author's view, be afforded for the use of the polyphase motor; lead lines of great length could be operated in the ordinary way, using high tension feeders with stationary transformers at the feeding points. 2½ cols.—*Elec. Rev.* (New York), Aug. 1st, 1900.

Electric Plant.—*Barnsley Electricity Supply Works.* Description of the municipal electric plant at Barnsley, a town of 42,000 inhabitants, with an area of 2,386 acres, and a ratable value of £88,000. (Ill.) 8½ cols.—*Elec. Engr.*, Sept. 21st., 1900.

—— *The Electricity Supply of Glasgow.* Description of the two new electric light stations of Glasgow, recently opened. (Ill.) 3¾ cols.—*Engr.* Sept. 14th, 1900.

—— *Glasgow Corporation New Electricity Works.* Description of the plant of the new works recently opened at Port Dundas and at Pollokshaws, Glasgow, by the Lord Provost and Bailie Maclay respectively. (Ill.) 3½ cols. —*Lghtng*, Sept. 20th, 1900.

—— *The New Electricity Works of the Glasgow Corporation.* First instalment of a communication describing the new works, dealing with the historical features of the enterprise, and giving an account of the works at Port Dundas. (Ill.) 6½ cols.—*Elec. Rev.*, Sept. 21st, 1900.

—— *Electrical Plant at Parkgate Steel Works.* Reprint of an article in the *Iron and Coal Trades Review*, in which the new electrical plant is described at the Works of the Parkgate Iron and Steel Company, of Rotherham, near Sheffield; the electrical machinery being supplied by the British Westinghouse Co. (Ill.) 5½ cols.—*Mech. Wrld.*, Sept. 14th, 1900.

—— *The Operation of a Combined Lighting and Power Plant.* By J. N. Perkins. Abstract of a paper read before the Ohio Electric Lighting Association at Toledo, Aug. 15th, 1900, describing the plant of the Youngstown Gas and Electric Company at Youngstown, O., U.S.A., of which the author is assistant manager. 4 cols.—*West. Electn.*, Sept. 1st, 1900.

—— *The Electric Generating System of Prague.* By Fred. Bathurst, A.M. (Conclusion.) This article concludes a very interesting contribution dealing with the electrical plant in the Bohemian capital, based on the principles of employing a closed primary and secondary distribution cable system with transformer stations of

large capacity, the cables being designed for small drop, and the transformers with close regulation; the employment of large accumulator batteries for the tramway service, so as to balance large load variations and to keep a nearly constant load upon the motor generators; the design of three-phase generating alternators with small drop between no load and full loads, so that small load differences of the three phases cause no appreciable difference of pressure in the branch circuits; the service of electric tramways by sufficiently large synchronous motor-generators, which are assured against surging by some efficient damping or choking arrangement. (Ill.) 5 cols.—*Elec. Rev.*, Sept. 14th, 1900.

Electrical Power Transmission.—*Electrical Power Transmission in Smelting Works.* Description of a very interesting plant at the works of the Smelting Corporation, Ltd., at their works at Ellesmere Port, Cheshire, designed by Mr. W. B. Devereux, assisted by Mr. R. Addie, who has since superintended their direction. (Ill.) 6½ cols.

—— *Regulation in Long-distance Transmission.* By Fred. A. C. Perrine. Abstract of a paper read before the Pacific Coast Electric Transmission Association, in which the author describes the regulation necessary at many different points of a transmission system, in order that a proper system of distribution may be obtained. 6 cols.—*Elec. Rev.* (New York), Aug. 15th, 1900.

Electrical Transmission.—*The Electrically-driven Plant of the Illinois Steel Company.* Description of the above-named plant at South Chicago, Ill., U.S.A., which shows in a striking manner the advantages to be derived from the use of electricity as a motive power in place of steam and other methods of driving, since this enormous industry has been enabled by means of electrical transmission to increase its output considerably and to effect a great saving. (Ill.) 1¾ col.—*Elec. Rev.* (New York), Aug. 29th, 1900.

Power Transmission.—*A large Power Installation in Sweden.* Description of a large plant for the transmission of power, erected at the Trangfors Waterfall, about 33 ft. in height, comprising six quadruple turbines with horizontal shafts, each of 300 effective horse-power, with 250 revolutions per minute. 1 col.—*Elec. Rev.* (New York), Aug. 15th, 1900.

Induction Motors.—*A New Method for starting Three-Phase Induction Motors.* The author describes an interesting device for starting three-phase induction motors invented by Mr. J. Fischer-Hinen, and in use in the Krizic establishment in Prague, Bohemia. (Ill.) 2 cols.—*Elec. Rev.* (New York), Aug. 15th, 1900.

Niagara Electric Plant.—*The New Wheel-pit at Niagara.* By Orrin E. Dunlap. The article deals with the extension of the Niagara Falls Power Company's power plant, especially the new wheel-pit, requiring the greatest excavation ever made, which will be finished about January, 1901, and the elaborate transporting and conveying machinery. 3 cols.—*Elec. Rev.* (New York), Aug. 15th, 1900.

Motors.—*Periodicity of Alternating-Current Apparatus.* By James M. Andrews. Abstract of a paper read before the Ohio Electric Light Association at Toledo, Aug. 15th, 1900, in which the author, after drawing attention to the strange fact that science often reverts to an original plan after having gone through various changes and modifications, as, for instance, returning to breech-loading guns after long experiments with muzzle-loading guns, and reverting to alternating-current apparatus after long trials with direct-current, proceeds to discuss the subject mentioned in the above title, and in order to present the matter as clearly as possible, and to cover all conditions that may arise, takes each periodicity separately and comments on its value as regards transformers, line losses, induction motors, synchronous motors, rotary convertors, lamps, and different systems. 4 cols.—*West. Electn.*, Sept. 8th, 1900.

Electric Motors.—*A Thermo-electric Motor.* Description of a very ingenious electric motor devised by Mr. Carl Mayer. The data of the article are taken from a German technical journal, the name of which is not mentioned. In this motor both the current necessary for the excitation of the field-magnets and that for rotating the armature is generated by the thermo-electric elements in the machine itself. (Ill.) 2 cols.—*Elec. Rev.*, Aug. 8th, 1900.

4. Telegraphy and Telephony.

Telegraphy.—*Gilmor Selector System of Typewriting Telegraphy.* Description of a new typewriting telegraph, which promises to be something more than a laboratory experiment, and was exhibited recently at Chicago, being the invention of Zalmon G. Sholes and Alfred C. Gilmor, of that city. One of the chief features of the invention is that the signals are transmitted over an ordinary telegraph line by dots and dashes, so that as far as the transmission is concerned, the requirements in no way differ from ordinary telegraph systems, and messages can be duplexed and quadruplexed on one wire, just as at present. (Ill.) 1½ cols.—*West. Electn.*, Aug. 4th, 1900.

Wireless Telegraphy.—*Molecular Changes produced in Matter by Electric Waves.* Abstract of a paper by Dr. Jagadis Chunder Bose, read before the Royal Society in February during the present year, in which the author repudiates the current theory regarding "coheres" action, which attributes the reduction of resistance in metal filings under the influence of electric waves to a kind of electric welding, and shows that the change of resistance produced in a substance by the action of electric waves is due to the formation of allotropic variations identical with the photographic action of the light on sensitive substances. 2½ cols.—*Elec. Rev.*, Sept. 21st, 1900.

5. Miscellaneous.

An Electrical Sensation.—*Edison's Latest.* The article, reproduced from the New York *Morning Journal* of Aug. 31st, contains a sensational announcement, stating that Edison is almost ready to make public his latest invention, which is nothing less than a scheme "approximate almost exactly to the production of electricity directly from coal." 2½ cols.—*Elec. Engr.*, Sept. 5th, 1900.

Current Distribution.—*On the Maintenance of certain portions of Distributing Systems at Earth Potential.* By C. H. Wordingham. Abstract of a paper read before the Municipal Electrical Association at Leeds, June 23rd, 1900, in which the author, who is the City Electrical and Tramways Engineer at Manchester, discusses the subject, dividing it into high-pressure and low-pressure circuits, and subdividing the latter into those circuits which have a conductor earthed at one point only, and those which are earthed at more than one point. 5¾ cols.—*Electy.* (New York), Sept. 12th, 1900.

Electrical Exhibits.—*Western Electric Company's Exhibit at Paris Exposition.* Description of the American exhibit of the Western Electric Company at the Paris Exposition, comprising exhibits in the sections for production and mechanical utilisation of electricity, for electric lighting, and for telegraphy and telephony. (Ill.) 1¾ col.—*West. Electn.*, Aug. 11th, 1900.

—— *Lahmeyer Exhibit at the Paris Exposition.* The article deals with the electrical exhibits of Messrs. W. Lahmeyer & Co., Ltd., electrical engineers and contractors, Frankfort-on-the-Maine, consisting of a 1,500 h.p. compound steam engine, running at 94 revolutions per minute, and two dynamos, one for 1,000 kw. three-phase current at 5,000 volts; the other at 400 kw. (maximum) at 500 volts, both being directly coupled to the engine shaft. (Ill.) 3 cols.—*Electy.* (New York), Sept. 12th, 1900.

Electric Heating.—*Electric Heating by the Blower System.* Description of a system consisting practically of small highly heated cylinders placed before a fan in a case suitably shaped to give the best intake and outgo of air. The motor is the standard type fan motor, consuming one-half ampère at 110 volts. (Ill.) 2 cols.—*Elec. Rev.* (New York), Aug. 8th, 1900.

Electricity Works.—*Rathmines Electricity Works.* Description of the new plant providing electricity for Rathmines, near Dublin, in which the direct current three-wire system is employed, supplying to customers at a standard pressure of 220 volts for lighting and small motors, and 440 volts for motors requiring more than 5 kw. (Ill.) 3½ cols.—*Elec. Rev.*, Sept. 14th, 1900.

Electric Meters.—*A Combination Integrating Wattmeter and Maximum Demand Indicator.* By J. N. Barker, M.I.E.C., A.M.I.C.E. Abstract of a paper read before the British Association at Bradford, in which the author, after a few general remarks on maximum demand, describes a meter, devised by himself in conjunction with Prof. Ewing, which measures both the total amount of electricity used and the maximum number of lamps, or their equivalent, ever lighted at one time. 2½ cols. *Elec. Engr.*, Sept. 7th, 1900.

—— *Auxiliary Power Recording and Indicating Electric Meters.* The article describes a very ingenious and novel type of electric meters, both indicating and recording, placed upon the market by the Whitney Electrical Instrument Company, through its general agents, Machado & Roller, New York. The principle on which the operation of these machines is based consists in causing the variations in the current to be measured, to control the variations in pressure of a body of air in a closed vessel, this variation being in turn indicated by the rise and fall of a column of non-volatile liquid in a glass tube, at the back of which is secured the scale. (Ill.) 3½ cols. *Elec. Rev.* (New York), Aug. 8th, 1900.

Insulating Materials.—*The Ethics of Insulating Materials.* By J. Wright. The author does not enter upon a discussion of insulating materials in general, but rather confines his remarks to a consideration of those substances, chief amongst which are india-rubber and gutta-percha, so largely employed for the insulation of electric cables and wires. 2¾ cols.—*Elec. Rev.*, Sept. 21st, 1900.

Storage Batteries.—*The Desirability of Using Storage Batteries in Medium-size Stations.* By S. G. White. The author endeavours to correct the prevalent idea that the storage battery is useful only for the purpose of storing energy and generating it during light-load periods, and shows that it possesses many other features of advantage, and is very valuable in medium-size stations. 2 cols.—*West. Electn.*, Aug. 25th, 1900.

Switches.—*Some New Motor-Starting Switches.* Description of two motor-starting switches manufactured by the Electrical Transmission Company, Ltd., of Albert Works, Hammersmith, and about to be placed on the market. They possess various interesting features, the essential novelty of which appears to be that the handle is not directly attached to the switch arm, but is only held to it by electro-magnetic means when the conditions are suitable. 1½ col.—*Elec. Engr.*, Sept. 14th, 1900.

—— *Starting Switches.* Description of a new type of motor-starting switch shortly to be placed upon the market by the Electrical Transmission Company, Ltd., under the patents of Mr. W. F. Jones, the chief feature of which is that the handle is not directly attached to the switch-arm, but is only held to it by electro-magnetic means when the conditions are suitable. (Ill.) 1 col.—*Elec. Rev.*, Sept. 21st, 1900.

MARINE ENGINEERING AND SHIPBUILDING.

1. Merchant Vessels.

Steamers.—*Passenger and Freight Steamer "Hartford," built for the New York and Hartford Transportation Co.* Description of a steamer built by the Columbian Iron Works of Baltimore, O., U.S.A., now carrying passengers and packet freight between New York and Hartford, being a twin-screw vessel of 1,488 gross registered tons, and having a cargo capacity of about 300 tons of ordinary freight, and accommodation for from 250 to 350 passengers. (Ill.) 2¾ cols.—*Mar. Engrg.*, Sept., 1900.

2. Pleasure Craft.

Yachts.—*The Clyde and Palatial Steam Yachts.* The article deals with the steam yacht *Lysistrata*, recently sent off the stocks by William Denny & Brothers, to the order of Mr. J. Gordon Bennett, and the *Margarita*, for Mr. A. J. Drexel, of Philadelphia, undergoing completion at Greenock. ¾ col.—*Engr.*, Sept. 14th, 1900.

3. Equipment and Machinery.

4. Docks.

Dry Docks.—*Flooding of the New Dry Dock Excavation at the Navy Yard.* By Frank O. Maxson, M.Am.Soc.C.E. The article deals with a third accident since December last, causing injury to the Boston Navy Yard dry dock, consisting of the flooding of the dock excavations through the overflowing of the clay bank, between the north end and west end wing of the dam, and the east end of the old line of quay wall, occurring about noon, August 26th, 1900. 4½ cols. *Engrg. Rcd.*, Sept. 22nd, 1900.

5. Miscellaneous.

Dredgers.—*Hopper Dredger "La Puissante."* Description of a powerful dredger launched on July 12th by William Simons & Co., Ltd., of Renfrew, and constructed to the order of the Suez Canal Co. for the improvement of the Port Said Roads. The contract dredging capacity was only 1,150 tons per hour, but on trial the dredger was found capable of raising 16,000 tons per hour. 1 col.—*Engr.*, Sept. 7th, 1900.

Electric Log.—*The McGray Electric Indicating Log.* Description of a log invented by Captain A. N. McGray, of Boston, and tested by the U.S.S. *Porter*, a high-speed torpedo boat. It consists of a rotating screw and a contact maker towed astern by a double conductor cable connected with a battery on board the vessel, and an indicating apparatus which is a simple revolution counter. (Ill.) 1½ col.—*Elec. Rev.*, Aug. 1st, 1900.

Lighthouses and Signals.—*Lighthouses and Audible Signals.* Constructed by Sautter-Harlé & Co. The article deals with the fine products of the above-named firm, whose manufacture of lenses dates back to the year 1852, and which occupies a foremost position in this special line. (Ill.) 2½ cols.—*Revue Technique*, Sept. 25th, 1900.

Ocean Rafts.—*Ocean Lumber Rafts.* Very interesting article, dealing with an industry peculiar to the Pacific coast of North America, namely, that of building immense pile rafts, which is mainly under the direction of Captain H. R. Robertson, who has supervised the building of similar but smaller rafts for 15 years on the Atlantic coast, and who during the past year or two has been in charge of the building of the most gigantic rafts ever built on the Columbia River and Puget Sound, one of which is in course of construction in the latter locality, to be towed to Japan. 1½ col.—*Mar. Engrg.*, Sept. 1900.

Tugs.—*Tug "Richard Croker," for Dock Dept., City of New York.* Description of a modern type of well-equipped harbour tug, constructed for the Department of Docks and Ferries of New York City by the Gas Engine and Power Co. and Charles L. Seabury & Co., Consolidated, Morris Heights, N.Y., U.S.A. 3¾ cols.—*Mar. Engrg.*, Sept. 1900.

MECHANICAL ENGINEERING.

1. Boilers, Furnaces, and Fuel.

Boilers.—*The Boilers of the Paris Exhibition.* Very interesting descriptive article on the boiler exhibit at the Paris World's Fair, which consists of two rows, in which the boilers are placed back to back, under a simple monitor roof of corrugated iron, with no enclosure upon the sides, in two courts, one for French and one for foreign manufactures. (Ill.) 18½ cols.—*Power*, Sept. 1900.

—— *The Wickes Vertical Water Tube Boiler.* Description of a water tube boiler primarily consisting of two cylinders or drums joined together by straight tubes, which are divided by a fire-brick tile passing through their centre into two compartments. (Ill.) 2½ cols.—*Power*, Sept. 1900.

2. Compressed Air.

3. Engines and Motors.

Automobiles.—*The Automobile Wagon for Heavy Duty.* Abstract of a paper presented at the Cincinnati meeting of the American Society of Mechanical

Engineers, in which the author points out the close relation between the progress of civilisation at large and the progress of transportation, and describes the gradual evolution of the automobile. (To be concluded.) 6 cols. —*Elec. Rev.* (New York), Aug. 15th, 1900.

Balancing of Engines.—*Balancing of Vertical Marine Engines, Discussed in an Elementary Manner.* By J. Macfarlane Gray. This first instalment constitutes an introduction to a contribution on the above subject, and dwells on the unavoidable and simultaneous compensation of a change of velocity in any direction. 6 cols.—*Mar. Engrg.*, Sept. 1900.

Engine Construction.—*The Standardisation of Engine and Machine Parts.* Digest of an address delivered by Prof. John E. Sweet, President of the Engine Builders' Association, in which he discusses the question of the standardisation of sizes and adoption of fixed rules in other matters in the building of engines, especially for direct connection to dynamos. 2¾ cols.—*Mech. Wrld.*, Aug. 31st, 1900.

Engines.—*The Lasier Gas Engine.* Description of a gas engine built in sizes ranging from 10 to 100 h.p. In the engines below ten h.p., the base is extended to the floor. The general design shows the utmost simplicity consistent with proper economy. (Ill.) 1¼ col.—*Power*, Sept. 1900.

—— *The Paris Exhibition.* Description of a new compound electric light engine exhibited by Robey & Co., Ltd. (Ill.) ¾ col.—*Engr.*, Sept. 21st, 1900.

—— *High Power Single-Cylinder Engines at the Paris Exhibition.* By E. Kilburn Scott. The author points out that in the French section of the Electricity Building in the Paris Exhibition are to be seen several examples of large horizontal single-cylinder engines, which in these days of high-speed engines is somewhat startling, and more so because in most cases they have been built for the avowed purpose of driving alternators. These engines are built up to 1,000 h.p. each, and though the adoption of a single-cylinder engine for such large powers seems strange, they have the undoubted advantages of extreme simplicity, cheap construction, and ease of repair, and appear to work very satisfactorily and without any sign of vibration. 1½ col.—*Elec. Rev.*, (New York), Sept. 7th, 1900.

—— *Reheaters in Multiple-Cylinder Engines.* By R. H. Thurston. This is the first instalment of an article on the subject above mentioned, and reviews the gradual development of the reheater from the time that John Bourne introduced this device in 1839. 3 cols.—*Mech. Engr.*, Sept. 7th, 1900.

—— *Reheaters in Multiple-Cylinder Engines.* By R. H. Thurston. This is the concluding portion of the paper dealing with the proper construction of a reheater and the essential principles on which it depends. 3¼ cols. *Mech. Wrld.*, Sept. 14th, 1900.

—— *Engine Breakdowns.* By Michael Longridge, M.A., M.Inst.C.E. This is a reprint of that portion of the annual report for 1899 by the author (who is chief engineer to the Engine, Boiler, and Employers' Liability Insurance Company), which contains the usual summary of engine breakdowns which have occurred during that period, and contains very interesting and classified information regarding the causes, and concerning the parts of the engines in which the breakdowns occurred. 6 cols. —*Mech. Engr.*, Sept. 15th, 1900.

—— *Prime Movers at the Paris Exhibition, No. VIII. French Section: Brêtrix, Nicolet & Co.* Description of an engine constructed by the above-named makers which represents considerable improvements in engine-building, especially as regards simplicity and rigidity. This engine is but a small one, registering 300 brak.-horse power; but the firm build up to 1,250 h.p. in the same pattern. (Ill.) 1½ col.—*Engr.*, Sept. 7th, 1900.

—— *Prime Movers at the Paris Exhibition, No. IX. Turbines.* The author points out that, although there is quite a large number of turbines exhibited, they are so scattered that a general review would be very difficult, and confines himself to some selected types, as, for instance, the turbines of Singrün Frères of Epinal, Trisset Vve., Brault and Chapron, John Jacob Rieter of Winterthur, Escher Wyss & Co., Zürich. 1¼ col.—*Engr.*, Sept. 21st, 1900.

Engines and Accessories.—*The Paris Exhibition. III.* Description of exhibits of Messrs. J. J. Rieter & Co., of Winterthur, at the Paris Exhibition, including a transmission dynamometer, and of Messrs. Chaligny et Cie., including a collection of horizontal and vertical steam-engines. (Ill.) 3 cols.—*Mech. Engr.*, Aug. 25th, 1900.

Engines for Electric Motors.—*The Sulzer Exhibit for the Paris Exhibition.* Description of the very fine exhibit of engines constructed by Sulzer Brothers, exhibited at Paris, notably a four-cylinder triple-expansion engine of 1,700 i.h.p., a tandem compound single-crank engine, coupled to a three-phase alternator by J. J. Rieter & Co., and a vertical double compound engine driving an Oerlikon Company's alternator. (Ill.) 1 col. —*Elec. Rev.*, Sept. 14th, 1900.

Machinery Exhibits.—*Clay-Working Machinery at the Paris Exhibition.* The article deals with the ever-increasing use of machinery for adapting clay to its manifold use-, and the mechanical appliances shown at the Exhibition, all of which, excepting one German and one American exhibit, are French. (To be continued.) 2 cols.—*Engrg.*, Sept. 21st, 1900.

4. Power and Transmission.

5. Machine Works, Shop and Foundry.

Foundries.—*Wellington Foundry, Lincoln.* Description of the works of Wm. Foster & Co., Ltd., situated at Firth Road, Lincoln, which—as in a large measure they are new works and have been equipped for the electrical driving of the machinery—contain many features of interest and instructive devices. 2½ cols.—*Engr.*, Sept. 7th, 1900.

—— *Foundry Management.* By Jos. A. Murphy. The author discusses the various conditions and the equipment required to make a foundry a paying concern. 5 cols.—*Am. Machy.*, Aug. 31st, 1900.

Machine Shops.—*Some Methods and Characteristics of a Berlin Tool Shop. I.* Description of the characteristic features of the tool shop of Messrs. Ldw. Loewe & Co., at Berlin, including an improved testing machine based on novel ideas, a device for testing squares, a testing-bar for lathe head stocks, and a drilling and facing jig. (To be concluded.) 6½ cols.—*Am. Machy.*, Sept. 6th, 1900.

6. Tools.

Machine Tools.—*Mechanical Engineering Exhibits at the Paris Exhibition.* The author draws interesting comparisons between the exhibits of the United States and those of other countries in this special line. He points out that as far as machine tools are concerned, the United States easily excel all other countries, and the exhibits at Vincennes conclusively prove this fact, although only a very small number of visitors, even of American visitors, go to see the annexe. He gives great credit, however, to the skill and ingenuity of the European workman, who, without modern mechanical appliances, produces the most excellent work, and states that as regards steam engineering Europe is far in advance of the United States, who in this branch are "sticking to ruts." (Ill.) 6 cols.—*Engrg. News*, Aug. 16th, 1900.

—— *The Paris Exposition. X. A New Threading Tool.* Description of a tool attracting considerable attention, namely, a threading tool to be used in the lathe, greatly simplifying the operation of threading lathe work, exhibited by Payson Bullard, at Vincennes, for its makers, the Rivett Dock Company, Brighton, Boston, Mass., U.S.A. This description is followed by one dealing with an improvement in screw cutting, shown by the Acme Machinery Company of Cleveland, Ohio, a "pipe facing" machine, exhibited at the Champ de Mars by George Prichards & Co., of Broadheath, near Manchester, England; a boring and turning mill by the same firm; a radial driller with tapping spindle, exhibited by the firm of Kendall & Kent, of Belle Vue, Manchester; and a miller of the planer type by the same firm. (Ill.) 5¾ cols.—*Am. Machy.*, Aug. 1900.

—— *Paris Exhibition. No. III.* The article deals with the English exhibit, which, when compared with the fine displays by the principal French firms, is not very

striking. The reason for this the author refuses to discuss, but it may, perhaps, become known one day; those that have been given to the public account only for certain cases. It appears, however, certain in the writer's eyes that those firms who were anxious to make an important exhibition were either not afforded the opportunity for doing so, or were actually hindered. The article points out that the firm with whose exhibits it especially deals—*i.e.*, Messrs. Kendall & Kent, of Manchester—were a case in point. (Ill.) 2¼ cols.—*Engr.*, Sept. 7th, 1900.

Machine Tools.—*Design and Construction of Machine Tools.* By Thomas R. Shaw. (Continued.) The present instalment deals with the lathe, its principle and its origin, the fast headstock, the back gearing, and examples of speed reduction. (Ill.) 5¾ cols.—*Mech. Engr.*, Sept. 1st, 1900.

—— *Design and Construction of Machine Tools.* By Thomas R. Shaw. (Continuation.) This instalment describes the sliding headstocks, the carriage and slide-rest, the self-acting motions, and the travelling stay on saddle. (Ill.) 5 cols.—*Mech. Engr.*, Sept. 15th, 1900.

—— *The Paris Exhibition. V.* This instalment deals with Messrs. Kendall & Gent's machine tools, of Belle Vue, near Manchester, including a Universal piano-milling machine, an improved vertical milling machine, and Dixon's patent radial drilling and tapping machine. (Ill.) 3½ cols.—*Mech. Engr.*, Sept. 8th, 1900.

Milling Machines.—*Some Applications of the Vertical Type-milling Machine.* The article describes some jobs carried out on the Becker-Brainard vertical type-milling machine, which comprise the reproduction of the machine itself. (Ill.) 1 col.—*Am. Mach.*, Sept. 6th, 1900.

7. Refrigeration and Cold Storage.

8. Miscellaneous.

Calorimeters.—*A New Form of Calorimeter for Measuring the Wetness of Steam.* By Prof. John Goodman. The author points out that it is quite impossible to accurately measure steam consumption of an engine unless the amount of moisture is known, and that several Continental steam engine makers who have a high reputation for economy owe a great deal of their reputation to the fact that they always specify the steam consumption in terms of an equivalent amount of "dry steam," a point which British makers seem not to appreciate. Of the two most common methods in use for measuring wetness, *i.e.*, the throttling or wire-drawing calorimeter, and the continuous condensing calorimeter, the former is now obsolete, owing to a false assumption on which it is based, and the latter are usually too cumbersome. He therefore describes a new continuous condensing calorimeter of a more portable design invented by himself. (Ill.) 3 cols.—*Elec. Engr.*, Sept. 7th, 1900.

MINING AND METALLURGY.

1. Coal and Coke.

Coal Handling.—*Coal-Handling Machinery.* By F. D. Marshall, Copenhagen. Abstract of a paper read before the Paris Congress, in which the author describes some of his experiences and the results obtained with various types of labour-saving machinery. (Ill.) 4¾ col.—*Gas Wrld.*, Sept. 8th, 1900.

—— *The Mechanical Handling of Coal and Coke in the Works of the Parisian Gas Company.* By J. Laverchère. The author gives a detailed description of the mechanical devices for handling coal and coke of the company named, who have a pictorial exhibit of their works at the Exhibition. (Ill.) 8¾ cols.—*Génie Civil*, Sept. 22nd, 1900.

—— *The Mechanical Handling of Coal and Coke in the Works of the Parisian Gas Company.* By J. Laverchère. (Conclusion.) (Ill.) 7¼ cols.—*Génie Civil*, Sept. 29th, 1900.

Coal Loading.—*The McLean-Gibson Coal-Loader.* Description of an Australian invention for loading coal into ships, which is shortly to receive a trial at Newcastle, the chief coal shipping port of the Antipodes. 1 col.—*Iron & Coal Trd. Rev.*, Sept. 28th, 1900.

Pit-Sinking.—*On a New Method of Sinking Pits by Machinery.* By Mr. Richard Sutcliffe, M.E. Abstract of a paper read before the Manchester Geological Society, in which the author, after drawing attention to the very primitive methods still prevailing in the sinking of pits, describes a machine designed by him to sink a pit of 20 ft. diameter, or 18 ft. finished within the walling, and states that he has found it competent to do all he claims for it. 5 cols.—*Iron & Coal Trd. Rev.*, Sept. 28th, 1900.

2. Copper.

Copper Assays.—*The Calorimetric Assay of Copper.* By J. D. Audley Smith. Abstract of a paper by the author read at the Canadian meeting of the American Institute of Mining Engineers, and describing a method devised for the purpose of doing away with preserved sets of standard calories, by making a fresh standard for each batch of assays. (Ill.) 1 col.—*Engrg. & Min. Journ.*, Sept. 15th, 1900.

Copper Ores.—*An Arizona Copper Exhibit at Paris.* Description of the exhibit of the mines and smelting works controlled by Phelps, Dodge & Co., of New York, comprising the Copper Queen Consolidated, at Bisbee; the Detroit, at Morenci; and the United Globe, at Globe. (Ill.) 1¾ col.—*Engrg. & Min. Journ.*, Sept. 22nd, 1900.

—— *Notes on the White Horse Copper Belt, Yukon Territory.* By R. H. Stretch. Description of the general surroundings and geological features of the above-named copper belt, which attracted a good deal of attention last autumn and the present spring on account of the large size of some of the mineral outcrops and the richness in copper of the specimens taken from a number of claims, of which more than 200 have been located, including quite a number of the so-called concessions, having an area of 160 acres each. 2¾ cols.—*Engrg. and Min. Jour.*, Sept. 8th, 1900.

—— *The Origin of the Native Copper in the Michigan Deposits.* By John F. Blaudy. The author refers to a chapter in "Kemp's Ore Deposits" (third edition, p. 209), in which the various theories and opinions regarding the origin of these ores are collated which were written since the issue of Foster & Whitney's report, and offers his own theory for the occurrence of these deposits. 2 cols.—*Engrg. and Min. Journ.*, Sept. 8th, 1900.

3. Gold and Silver.

Gold Mining.—*Gold Mining in Nova Scotia.* By G. H. Stuart. The author gives a short historical review of the gold-mining industry in the part of the Dominion above-mentioned, and describes the present condition of the mines, suggesting that the cause of so little being known about Nova Scotia's mining resources may be due to the great accessibility of the province, which renders it less romantic than more remote districts. (Ill.) 2¾ cols.—*Engrg. and Min. Journ.*, Sept. 15th, 1900.

4. Iron and Steel.

Bessemer Process.—*The Metallurgy of Iron and Steel.* By Prof. A. Humbert Sexton, F.I.C., etc. (Continued.) This instalment deals with the Bessemer process, explaining the principle, giving a brief outline of the process, a description of a blow, and an outline of Bessemer's description. (To be continued.) 3½ cols. (Ill.)—*Mech. Engr.*, Sept. 29th, 1900.

Carburised Iron.—*The Present Position of the Solution Theory of Carburised Iron.* By A. Stansfield. Abstract of a paper read before the Iron and Steel Institute. The author, who, in the autumn meeting of 1899, presented a paper to the Institute giving an outline only of the solution theory, without any attempt to reconcile apparently contradictory facts with this theory, makes in the present paper, which may be called a continuation of the former, an effort to review as far as possible all the experimental evidence that appears to bear upon the subject, and also to incorporate the results of some fresh experiments of his own. 2 cols.—*Iron and Coal Trds. Rev.*, Sept. 28th, 1900.

Cast Iron Tests.—*The Influence of Aluminium on the Carbon in Cast Iron.* By Godfrey Melland, B.Sc., and Harry W. Waldron. Description of a research by

the authors to determine the amount of aluminium necessary to produce the maximum separation of graphite in a white iron as free as possible from impurities, and to ascertain the effect of slow and rapid cooling. 6½ cols. —*Mech. Engr.*, Sept. 29th, 1900.

Iron and Steel Rolling.—*Suggestions for the Improvement of Rolling Mills.* By Louis Katona, Resicza, Hungary. Abstract of a paper read before the Paris meeting of the Iron and Steel Institute, Sept. 1900, in which the author considers the various types of rolling mills in existence with reference to four distinct factors—*i.e.*, the engine or driving motor, the fly wheel, compensating for the irregular action of the engine, the power-transmission gear, and the rolls themselves, and, pointing out the defects of the various types, suggests improvements. 3½ cols.—*Iron & Steel Trds. Journ.*, Sept. 29th, 1900.

Iron Works Equipment.—*A New Apparatus for Charging Blast Furnaces.* Description of a new design for charging apparatus for blast furnaces, being of the double-ship car type, which possesses the advantages of both the usual double and single-ship hoists, without the characteristic disadvantages of either. (Ill.) 1 col.—*Coll. Guard.*, Sept. 28th, 1900.

Steel Manufacture.—*Shop Notes at Bethlehem.* The article deals with the remarkable results as regards cutting speeds by means of tools treated by the Taylor-White process at the works of the Bethlehem Steel Company, U.S.A., and describes some views of the plant reproduced, together with the article. 2 cols.—*Ry. & Engrg. Rev.*, Sept. 8th, 1900.

5. Mining and Mining Methods.

Rock Drills.—*The Ingersoll-Sergeant Drill Company's Paris Exhibit.* Description of one of the most extensive exhibits of the United States, this New York firm showing air-compressing, mining, tunnelling, and quarrying machinery in their places at the Exhibition. At the Champ de Mars, in the Palace of Machinery and Electricity, it has its headquarters at the U.S. Machinery Section. (Ill.) 1¾ col. *Engrg. & Min. Journ.*, Sept. 15th, 1900.

6. Miscellaneous.

Metallurgical Progress.—*A New Method of Producing High Temperatures.* Abstract of a paper by Mr. Ernest F. Lange, F.C.S., Manchester, read before the Iron and Steel Institute, Sept. 1900, in which the author describes the experiments he witnessed in company with Mr. Henry Cooper, of Messrs. Vickers, Sons & Maxim, at Essen, at the works of the Chemical Thermo-Industrial Company, showing the efficiency of Dr. Hans Goldschmidt's method of employing the heat energy developed by the chemical action of aluminium upon certain metallic oxides. (To be continued.) 4½ cols. *Engrs'. Gas.*, Oct. 1900.

Metallurgy.—*Metallurgical Processes in England and France.* Extracts from the Presidential Address of Sir William Robert Austen, K.C.B., F.R.S., delivered at Paris at the meeting of the Iron and Steel Institute, Sept. 18th. 1⅛ col.—*Journ. Soc. Arts*, Sept. 21st, 1900.

MUNICIPAL ENGINEERING.

1. Gas Supply.

Cyanides in Gas Works.—*The Production and Manufacture of Cyanides in Gas Works.* Abstract of a paper by Dr. Bueb, of Dessau, read at the Gas Congress in Paris, in which he describes a method devised by him for extracting at little cost the whole of the cyanogen in a form in which it is very valuable. 2½ cols.—*Journ. of Gas Lghtng.*, Sept. 18th, 1900.

Gas Distribution.—*The Reduction of the Cost of Distribution by the Use of High Pressure.* Abstract of a paper by Mr. Frederick H. Shelton, Philadelphia, Pa., U.S.A., read before the International Gas Congress in Paris, in which the author makes a strong plea in favour of the increase of pressure in the distribution of gas, which, though crude and rough as yet, has commenced, and, if generally adopted, will result, in the author's opinion, in great economy. (Ill.) 8 cols.—*Journ. of Gas Lghtng.*, Sept. 25th, 1900.

Gas Lighting.—*Chemistry Applied to Gas Lighting.* This is a review of "Chemical Technology, or Chemistry in its Applications to Arts and Manufactures," edited by Charles Edward Groves, F.R.S., and Wm. Thorp; Vol. III., "Gas Lighting," by Charles Hunt, Engineer of the Birmingham Corporation Gas Works. London: J. & A. Churchill, 1900. The reviewer comes to the conclusion that the volume as a whole will prove a disappointment to most readers, since it is hardly worthy of a specialist of Mr. Hunt's experience, and, what is worse, is out of date. 2½ cols.—*Journ. of Gas Lghtng.*, Sept. 25th, 1900.

Gas Motors.—*Some Existing Gas-Driven Power Plants.* By Ph. Dawson. The article is a first instalment of a contribution on the subject, and reviews historically the development of the use of gas engines for driving dynamos. The first plant described is one put up in 1894 at Zurich to run the "Zurich Bergbahn." (Ill.) 3 cols.—*Engrg.*, Sept. 7th, 1900.

Gas Retorts.—*Inclined Retorts.* By C. E. Brackenbury, London. Abstract of a paper read by the author before the Paris International Gas Congress, in which he draws attention to the enormous increase of the use of inclined retorts in Europe, and describes the most efficient methods of working them. 2½ cols.—*Gas Wld.*, Sept. 8th, 1900.

Incandescent Gas Light.—*Care of High-Pressure Incandescent Gas Lights: a New Installation.* The article draws attention to the fact that the trials of intensified gas lighting continue to extend, which shows that the local authorities begin to see that "there is something in it," and then describes an installation recently completed by the Intensified Gas Light Company in the large refuge lamps opposite the Law Courts, in the Strand, London, for the Strand Board of Works. (Ill.) 1½ col.—*Journ. of Gas Lghtng.*, Sept. 18th, 1900.

Naphthalene Obstructions.—*A Method of Preventing Naphthalene Obstructions.* By Dr. Bueb, of Dessau. Abstract of a paper read before the International Gas Congress at Paris, in which the author refers to the fact that naphthalene occurs among the various hydro-carbons formed in gas-retorts during the distillation of coal, and gives considerable trouble to gas engineers; after which he describes a method that has been industrially applied at the large works of the German Continental Gas Company, at Dessau, by which naphthalene can be abstracted from illuminating gas in a simple and inexpensive manner. 1 col.—*Journ. of Gas Lghtng.*, Sept. 18th, 1900.

2. Sewerage.

Sewerage Systems.—*Municipal Sewerage Systems and Assessments.* Abstract of a paper presented to the American Society of Municipal Improvements by Geo. T. Bonten, Jersey City, N.J., U.S.A. 2¾ cols.—*Engrg. Rcd.*, Sept. 22nd, 1900.

Sewer Trenching.—*Deep Sewer Trenching.* The article deals with the above subject in connection with the Green Avenue relief sewer, between Broadway and Bushwick Avenue, borough of Brooklyn, New York, built of brick, and being 78 ins. interior diameter, while the invert is from 35 to 40 ft. below the street. (Ill.) 2½ cols.—*Engrg. Rcd.*, Sept. 1st, 1900.

3. Streets and Pavements.

Asphalt Mixtures.—*The Value of Chemical Tests of Asphalt Mixtures.* Abstract of a paper read before the Am. Soc. of Municipal Improvements, by W. H. Broadhurst, chemist, Department of Highways, New York City, in which the author refers to the specifications now in use for laying pavements in New York City, containing a general clause with regard to the character of the composition to be used and to the test required to insure the desired uniformity. 2½ cols.—*Engrg. Rcd.*, Sept. 1st, 1900

Pavements.—*Construction and Maintenance of Brick Pavements.* Abstract of a paper presented at the Milwaukee Convention of the American Society of Municipal Improvements by Mr. E. A. Kemmber, Assistant City Engineer of Columbus, O. 6½ cols.—*Engrg. Rcd.*, Sept. 22nd, 1900.

—— *The Construction of Asphalt Pavements.* Abstract of a paper read by Mr. Geo. W. Tillson, M.Am.Soc.C.E., in which the author points out that the first asphalt pavement in the United States was laid in New York just thirty years ago, that after that time a great many experiments were made to test the durability of such pavements and to ascertain the best methods, and that, since careful records were kept of the methods employed, we are now able to state with comparative certainty which is the best method of construction. He then proceeds to describe such a method. 3¾ cols.—*Engrg. Rcd.*, Sept. 1st, 1900.

Street Cleansing.—*Recent Developments in Cleansing.* By Bailie Brechin. Abstract of a paper read at the Salford Meeting of the Association of Cleansing Superintendents, in which the author deals with certain novel methods introduced into the street-cleansing of Glasgow, comprising the hose-washing of streets, the separate collection of waste-paper, and the utilisation of clinker. (Ill.) 3 cols.—*Pub. Hlth. Engr.*, Sept. 8th, 1900.

Street Watering.—*Some Actual Working Costs of Motors for Street Watering and Dust Removal.* By E. Shrapnell Smith. Abstract of a paper read Aug. 30th at the annual meeting of the Association of Cleansing Superintendents of Great Britain, held in the Town Hall at Salford. 2¾ cols.—*Engr.*, Sept. 14th, 1900.

4. Water Supply.

Water Waste.—*Localising and Preventing Water Waste.* Extracts from a report by Mr. J. James Croes, M.Am.Soc.C.E., to the Engineering Committee of the Merchants' Association of New York, dealing with his efforts to discover the cause of an increase in the use of water and its legitimacy. 4¾ cols.—*Engrg. Rcd.*, Sept. 8th, 1900.

Waterworks.—*Bradford Waterworks, Old and New.* By James Watson, M.Inst.C.E. The author reviews the gradual development of the waterworks at Bradford, from their earliest beginnings in 1744 to the most recent times. (Ill.) 4 cols.—*Engr.*, Sept. 14th, 1900.

5. Miscellaneous.

Municipal Engineering.—*Present Problems in Municipal Engineering.—I.* Slightly condensed report from an address before the Paris Convention of the Sanitary Institute, by Mr. Thomas De Courcy Meade, M.Inst.C.E., the presiding officer. This first instalment deals mainly with the difficulties arising from the pollution of rivers and streams by sewage and manufacturers trade refuse. 4¾ cols.—*Engrg. Rcd.*, Sept. 1st, 1900.

Refuse Destructors.—*The Disposal of House Refuse in Bradford.* By J. McTaggart, A.M.I.M.E. The author describes a test with refuse destructors continuing without interruption a complete fortnight, which, he says, is the shortest period for obtaining a reliable test, as all shorter tests give merely fictitious results. 4 cols.—*Elec. Rev.*, Sept. 14th, 1900.

NAVAL AND MILITARY ENGINEERING.

1. War Vessels.

Cruisers.—*Protected Cruisers of the Denver Class for the U.S. Navy.* The article deals with a vessel of a type in which the United States Navy Department has made a marked departure from recent practice in one notable particular, namely "speed." (Ill.) 3 cols.—*Mech. Wrld.*, Aug. 31st, 1900.

Destroyers.—*U.S. Torpedo Boat Destroyer "Dale."* Description of the first of the 16 destroyers now being built by the United States Government. The launch, being a "side launch," created unusual interest, and was witnessed by upwards of 5,000 people. (Ill.) 1¼ col.—*Mar. Engrg.*, Sept. 1900.

2. Equipment.

3. Armour Plates, Guns and Ammunition.

Gun Making.—*The Construction of "Long Cecil."* By Ed. Goffe, of Kimberley. Abstract of a paper read before the British Institute of Mechanical Engineers, in which the author describes the construction of the interesting gun cast by Mr. Labrom during the siege of Kimberley. 11½ cols.—*Am. Mach.*, Aug. 30th, 1900.

—— *Krupp's Modified Welin Breech Screw.* Extracts of an article in the *International Review* for August, giving a description, with cuts, of the modified Welin breech screw adopted by Krupp. In the modified screw the inclined faces of the screw heads are suppressed, but the general form remains unaltered. (Ill.) ¾ col.—*Engr.*, Sept. 7th, 1900.

4. Miscellaneous.

War Material.—*War Material at the Paris Exhibition. No. II.* The article deals with the products of Messrs. Vickers, Sons & Maxim, Ltd., who are the only English firm exhibiting in this class, but whose exhibits are so excellent as to be well able to maintain England's reputation. (Ill.) 3 cols.—*Engr.*, Sept. 21st, 1900.

RAILWAY WORK.

1. Motive Power and Equipment.

Locomotive Building.—*Heavy Pneumatic Forging Machine.* Description of a very powerful pneumatic forging machine in course of erection at the Burnside shops of the Illinois Central Railroad, which will perform all the functions of a forging machine, riveting machine, and a bulldoger, and seems not improperly to be called a "mechanical blacksmith." (Ill.) 1¾ cols.—*Am. Engr. & Rld. Journ.*, Sept. 1900.

Locomotives.—*20-ft. Boiler Tubes for Locomotives.* The article deals with the increasing tendency toward lengthening locomotive boiler tubes, which is likely to receive considerable impetus through the influence of wider fire-boxes for bituminous coal. There seems to be but one anxiety in the use of long tubes, that concerning the expansion and contraction, and its effect upon leakage at the tube sheets—a fear which may prove without foundation; and, moreover, there is a simple remedy in cambering the tubes by giving them a slight bend before placing them in the boiler. 1¾ col.—*Am. Engr. & Rld. Journ.*, Sept. 1900.

—— *Locomotive Exhibits at Vincennes.* The article deals with the most prominent exhibits at the annexe to the Paris Exhibition, and draws attention to the fact that there is an enormous preponderance of compound over non-compound engines, except in the British exhibit, where there is only one compound engine, Mr. F. W. Webb's four-cylinder compound engine, "La France," among the six locomotives exhibited. 2½ cols.—*Engr.*, Sept. 14th, 1900.

—— *The Mallet Articulated Compound Locomotive.* Abstract of an article by the inventor of this type of engine in the *Revue Générale des Chemins de Fer*, showing the wide application of this locomotive at present, although it was originally intended for special purposes. (Ill.) 1¼ col.—*Rld. Gaz.*, Sept. 14th, 1900.

—— *German Locomotives at the Paris Exhibition.* The present instalment of this series of contributions deals with a very interesting locomotive built at the large works of Messrs. Maffei & Co., of Munich, an articulated engine of the Mallet system. 1¼ col.—*Engrg.*, Sept. 7th, 1900.

—— *Wightman's Cylinder and Frame Fastening.* Description of a new and very substantial structure between the cylinders and frames of very large engines to secure strength, used in the Locomotive Works of the

Pittsburgh, Bessemer and Lake Erie Railroad, designed by Mr. D. A. Wightman, General Manager of Works. (Ill.) 1 col.—*Am Engr. & Rld. Journ*, Sept. 1900.

Locomotives.—*Wigzell's Double Triple-Expansion Engine.* Description of a double triple-expansion engine, invented by Mr. E. E. Wigzell, of Billiter House, Billiter Street, London, E.C., being one of 350 i.h.p., which is being constructed for the Central Cyclone Company, London, by Messrs. Pollit & Wigzell, Ltd., engineers, Bank Foundry, Sowerby Bridge. (Ill.) 4 cols.—*Engrg.*, Sept. 7th, 1900.

—— *Decapod Compound Locomotive for the Minneapolis, St. Paul and Sault Ste. Marie Ry.* Description of a ten-wheel engine recently built by the Baldwin Locomotive Works, Philadelphia, Pa., for the above-named railway, which is to work between Minneapolis and Pennington, Wis., U.S.A., 165 miles. 2 cols.—*Engrg. News*, Sept. 20th, 1900.

—— *The Paris Exhibition—Borsig Locomotive, with Superheater.* Description of a very interesting type of locomotive, devised to solve in a very original manner the problem of avoiding the immense losses due to cylinder condensation. (Ill.) 1¾ col.—*Engr.*, Sept. 7th, 1900.

2. New Projects and Lines in Construction.

New Lines.—*The New Competitor.* By W. J. Scott, B.A. Interesting article on the Great Central Railway, its origin, its vicissitudes equipment, defects, achievements, and the promises of the future. (Ill.) 18 cols.—*Ry. Mag.*, Oct. 1900.

3. Permanent Way and Fixtures.

Railway Equipment.—*A Remarkable Round-house—Chicago and North-Western Railway.* Description of the new round-house at Clinton, Iowa, recently completed by the Chicago and North-Western Railway, which is interesting both in design and construction, and contains many novel and practical features. (Ill.) 2⅞ cols.—*Ry. Master Mech.*, Sept. 1900.

Railway Locks.—*Electric Signal Locks.* By E. M. Floyd, Engineer's Office, Belfast and Northern Counties Railway. The author discusses various systems of interlocking tried on some lines, and their merits and defects, and the reasons for the almost universal adoption of the system known as "the Sykes." (Ill.) 7⅜ cols.—*Ry. Mag.*, Oct. 1900.

Railway Stations.—*Notable Railway Stations. No. VIII., Temple Meads, Bristol.* Description of one of the largest and most graceful structures of the kind in Great Britain, being also of historical interest, as the original old portion, designed by Brunel, still forms a part of the station. (Ill.) 8½ cols.—*Ry. Mag.*, Oct. 1900.

4. Transportation and Conducting.

5. Miscellaneous.

Centrifugal Railway.—*Coney Island Centrifugal Railway.* Description of the Boyton centrifugal railway, which is certainly a novel application of centrifugal force. It consists of an elevated inclined track, curving upward and downward near its middle, to form an oval loop, the vertical (major) axis of which is 24 ft. long, and the horizontal (minor) 20 ft. long; the cars are 6 ft. by 3 ft. The highest point of the railway is 35 ft. from the ground, and between this point and the oval loop is a stretch of 75 ft. in length. The car, previously hauled up by a cable, after being released, rushes down the incline with constantly-increasing velocity, whirls around the loop, and reaches the station running up a heavy grade. (Ill.) ¾ col.—*Sci. Am.*, Sept. 22nd, 1900.

Light Railways.—*The Basingstoke and Alton Light Railway.* By Arthur Kelly. Description of this railway, having a length of line of 12¾ miles, which will shortly be opened to traffic. It was the first light railway sanctioned by the Light Railway Act, which came into operation in 1896. It was, however, not the first finished since the Rother Valley Railway, for which the concession was obtained at a later date, was opened to traffic some months ago. (Ill.) 8½ cols.—*Ry. Mag.*, Oct. 1900.

Light Railways.—*The Clogher Valley (Light) Railway.* By E. Hurst. Description of the first narrow-gauge line, the first constructed under the Tramways (Ireland) Act of 1883, which owes its being to the efforts of a number of local landowners and other gentry, and which, though not deriving any appreciable aid from tourist traffic, has, handicapped though it is in many ways, more than fulfilled the hopes of its originators in cheapening provisions and rates of carriage, as well as in awakening the inhabitants of the district to its future possibilities. (Ill.) 7½ cols.—*Ry. Mag.*, Oct. 1900.

Mountain Railways.—*The Mount Pilatus Railway.* By Ronald L. Pearse. The article is devoted to the description of one of the most remarkable mountain railways in Europe, which makes the ascent of Mount Pilatus, on the Lake of Lucerne, and originated with Colonel Locher and Mr. E. Guyer-Frenler, of Zurich, in 1885. It was begun in the summer of 1886, and completed, for the remarkably moderate sum of £76,000, in August, 1888 5¾ cols.—*Ry. Mag.*, Oct. 1900.

Railroad Construction.—*Ten Spindle Rail Drilling Machine.* Description of a machine built to drill holes for the rods in switch rails, the holes being drilled in pairs, and the holes in each pair being at a fixed distance of 5 ins. (Ill.) 1 col.—Sept. 13th, 1900.

Railroad Police.—*Railroad Police Organization and the Tramp Problem.* Abstract of a paper read before the annual meeting of the Central Association of Railroad Officers at Louisville, Ky., U.S.A., on July 17th, 1900, dealing with a subject of considerable importance, as will be granted when it is known that every night 10,000 free passengers of the tramp genus travel on different railroads in the United States, and 10,000 more are waiting at watering tanks and in railroad yards for opportunities to get on the trains. The entire tramp population is estimated at 60,000, of whom a third are generally on the move. (To be continued.) 2 cols.—*Ry. & Engrg. Rev.*, Sept. 1st, 1900.

Railways Equipment.—*Automatic Ash Elevator, Operated by Pneumatic Power.* Description of a very practical and efficient device for handling locomotive ashes and cinders, designed by Mr. G. R. Henderson, Assistant Superintendent of Motive Power, and built by the Motive Power Department of the Chicago and North-Western Ry., U.S.A. (Ill.) 1½ col.—*Am. Engr. & Rld. Journ.*, Sept. 1900.

—— *At the Paris Exhibition. The United States Transportation Exhibits at Vincennes. Illustrated and described.* The article comprises a concise review of the most important exhibits in the "transportation sheds" of the United States section. 5 cols.—*Ry. Age*, Sept. 14th, 1900.

Traction Engines.—*American Traction Engines for Russia.* Description of two traction engines and eight steel wagons recently shipped by the Best Manufacturing Co., of California, U.S.A., to Siberia, where they will be used as a substitute for camel-trains in hauling supplies to the mines. (Ill.) 1 col.—*Engr.*, Sept. 28th, 1900.

STREET RAILWAYS AND TRAMWAYS.

1. Trolley Lines.

Electric Traction.—*Overhead Construction, with Special Reference to Guard Wires.* By Sidney Woodfield. The author expresses his agreement with a paper on the subject by Mr. Quin, as regards the latter's view that guard wires are a nuisance, and in many instances are greater dangers than those which they are intended to avert, and then enters upon an inquiry into the causes of the accidents, the majority of which are due to the trolley jumping the trolley wire and getting caught in the guard or span wires. 3½ cols.—*Elec. Rev.*, Sept. 21st, 1900.

Trolley Systems.—*Sunderland Corporation Electric Tramways.* Description of the interesting tramway system of the Corporation of Sunderland, which, on March 1st, 1900, bought up the undertaking of the Sunderland Tramway Company, consisting of about five miles of tramways worked by horse traction, for £35,000, although the capital invested by the company amounted to £73,361, and had obtained in 1879 an Act of Parliament giving it all necessary powers for the construction of an electric tramway system of 23·8 miles in length. Mr. J. F. C. Snell, the electrical engineer of the Corporation, drew up specifications and plans, and in September, 1899, a contract, amounting to £126,000, for 12 miles of permanent way, the electrical equipment, and the rolling stock, was let to Messrs. Dick, Kerr & Co., Ltd. The first section, opened on Aug. 15th, 1900, comprises 4 mls. 1 fur. of single track, and extends from Roker to Christ Church. 6¼ cols.—*Tramw. & Railw. Wld.*, Sept. 1900.

—— *The Electrical Equipment of the Manhattan Elevated Railway.* The article deals with the progress of the work and some of the details of this important electric traction plant in the United States, the total capacity of the power-house of which, under normal load and most economical conditions, will be 64,000 h.p. 3 cols.—*Elec. Rev.* (New York), Aug. 1st, 1900.

—— *Southport Corporation Electric Tramways.* The article deals with the new electric tramway system at Southport and the opening of the section so far completed, and comprising 5½ miles, on July 18th. This first section represents the satisfactory adjustment of a local problem that had exacted from the Town Council, and especially the Tramways Committee, much work and patience. (Ill.) 7½ cols.—*Tramw. & Railw. Wld.*, Sept. 6th, 1900.

—— *The Swansea Tramways.* Description of a tramway system officially opened for electric traction on June 30th of the present year, after having passed through a rather chequered career. The total length of route is 5 mls. 3 furs., part of which is double and part of which is single track, with frequent curves, the radius of the sharpest curve being 40 ft. (Ill.) 10 cols.—*Tramw. & Railw. Wld.*, Sept. 6th, 1900.

Electric Locomotives.—*The Standard-Gauge Electric Locomotive, exhibited by the "Allgemeine Elektricitäts-Gesellschaft" at the Paris Exhibition.* Description of a locomotive constructed by the above-named firm for the haulage of goods and passenger trains on branch lines and for shunting purposes upon standard-gauge tracks of 3 ft. 11 ins. (Ill.) 3½ cols.—*Elec. Engr.*, Sept. 28th, 1900.

Electric Locomotives.—*The Paris Exhibition—Electric Locomotive.* Description of an electric locomotive intended for working a rack railway, as well as on smooth rails, shown at Paris by the makers, "La Société Suisse," of Winterthur. The engine has been constructed for the Fourvière et Ouest-Lyonnais Railway, Lyons (Ill.) ¾ col.—*Engr.*, Sept. 28th, 1900.

Meters.—*A Meter for Measuring Traction Force on Electric Tramways.* By Gisbert Kapp. Translation of a summary of a paper read at the eighth annual meeting of the Union of German Electrical Engineers, at Kiel, describing an apparatus of the above kind which has been tested by the inventor on one of the Berlin tramways and at the high-speed railway of Siemens & Halske at Lichterfelde. 4½ cols.—*Elec. Rev.* (New York), Sept. 5th, 1900.

Tramway Brakes.—*Brakes for Tramway Cars.* Digest of a highly interesting report of competitive tests of street-car brakes recently carried out by the Board of Railroad Commissioners of the State of New York, U.S.A. 5 cols.—*Tramw. & Railw. Wld.*, Sept. 1900.

From the "SHEFFIELD DAILY INDEPENDENT" of Oct. 10, 1900.

"Feilden's Magazine" for October is one of the finest examples of engineering magazines we have yet seen. The paper, printing, and engraving are perfect. The selection of articles is sufficiently varied to cover almost every department of industrial progress. The literary quality of the contributions is of the best. Amongst the subjects treated upon in the leading articles are "Traffic Facilities," "Utopian Sewage Treatment," and the "Prevention of Strikes." We are pleased to notice that in the last-named article the ust and temperate attitude adopted throughout the Taff Vale negotiations by Mr. Bell, the secretary to the A.S.R.S., is acknowledged, and the assistance Mr. Bell gave in preventing the threatened strike on the Great Eastern Railway is also favourably mentioned. An article on "Electrical Methods of Heating" is full of new information. Capt. Tulloch's description of "Quick-Firing Guns for Field Artillery Use" is likely to attract some notice at the present time, and Mr. W. N. Twelvetrees continues his descriptive article on "The Central London Railway." These by no means represent the total contributions to "Feilden's Magazine," but will indicate to the technical and non-technical reader the value of such a publication to all associated with industrial and engineering production.

TRADE AND ECONOMICS.

1. Commerce and Trade.

2. Industries.

Clay-Working.—*Clay-Working Machinery at the Paris Exhibition* (continued). This instalment describes various continuous brick-making machines of French origin, and also one made by the American Clay-Working Machinery Company, of Bucyrus, called the "Giant Auger Machine." (To be continued.) 2¾ cols.—*Engrg.*, Sept. 28th, 1900.

Coal Famine.—*American Coal in London and Europe.* Commenting on the arrival of the steamer *Queenswood*, with a load of something less than 4,000 tons of Philadelphia gas coal, in London, the writer says that, of course, it is impossible that American coal will ever be able to compete with our home product, but the fact itself has, nevertheless, its significance, and should serve as a reminder to British coal-owners that there is a limit to their monopoly. 1 col.—*Journ. of Gas Lghtng.*, Aug. 28th, 1900.

Iron and Steel Trades.—*The Position of the Iron and Steel Trades.* The author refers to the significant incident which recently occurred in Glasgow, namely, that the secretary of the pig-iron ring was presented by the members with a pair of white gloves to commemorate an event that had not happened for many years, *i.e.*, that not a single transaction took place that day at the meeting of the Glasgow iron market, and demonstrates that the outlook in the iron and steel trades grows more gloomy from day to day, owing to a slack demand and the increasing assertiveness of foreign competition. ¾ col.—*Journ. of Gas Lghtng.*, Sept. 25th, 1900.

2. Surface Contact Lines.

3. Miscellaneous.

Electric Traction.—*The City and South London Railway.* Description of the equipment of this railway, inaugurated about 10 years ago, and of special interest as being the pioneer underground electric railway. Up to the present this line has had an uphill fight, but much is expected from the extensions to Clapham and Moorgate Street, and especially from that to Islington. (Ill.) 6½ cols.—*Elec. Rev.*, Sept. 7th, 1900.

3. Labour.

4. International Relations.

5. Miscellaneous.

Development of South Africa.—*Advice to Emigrants. No. I. The Possibilities.* This is the first of a series of articles offering advice to those who contemplate going out to settle. The series will deal with the general view, the voyage out, the overland transport, and the resources of the various Colonies, with the openings therein for settlers. 3½ cols.—*South Africa*, Sept. 22nd 1900.

Development of South Africa.—*Advice to Emigrants. No. II.* This, the second instalment of the series, begins with comments on the settlement of time-expired soldiers—which, though the scheme proposed by Lord Beaconsfield with reference to India fell through, promises great success in South Africa—and then proceeds to describe the voyage out from Southampton to Cape Town, a distance of 5,981 miles. 4 cols.—*South Africa*, Sept. 29th, 1900.

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REVIEWS.

The Automotor and Horseless Vehicle Pocket Book of Automotive Formulæ and Commercial Intelligence for 1900. London: F. King and Co., Ltd., 62, St. Martin's Lane, W.C., 1900. Price: Boards, 1s.; limp cloth, 2s.

The third edition of this pocket-book is, excepting slight additions, a reprint of the previous issue, but the formulæ and data given are nevertheless quite up to date, as no startling changes have occurred during the past year in the construction of automobiles. The publishers have the intention of issuing, in the near future, the pocket-book in two distinct parts, and separating the technical from the commercial data, which will certainly be an improvement, since in a *vade mecum* the bulk should be reduced as much as possible, and few automobilists will care to carry constantly with them a directory of manufacturers, etc., which they would rarely wish to consult except at their desk. The material of the first portion of the little book, on the other hand, is well selected, and the tabulated data give just such information as it may be desirable to obtain at any moment while travelling, especially where there is no access to a library. The little technical dictionary at the end of the book, giving the most important technical terms connected with automobilism in three languages, is a very praiseworthy feature; but it may be asked why, although there is a French-German-English and an English-French-German portion, the German-French-English portion is omitted. The compilation can require but little labour, and would not add much to the book, while it would be certainly useful to automobilists travelling in Germany or Austria. The get-up of this pocket-book, with its flexible binding and clear print, is very neat, and the little volume will certainly be acceptable to most automobilists, the price being very moderate.

Diamond Drilling for Gold and Other Minerals. A Practical Handbook on the use of the Modern Diamond Core Drill in Prospecting and Exploiting Mineral-bearing Properties, including the Particulars of the Cost of Apparatus and of Working. By G. A. Denny. London: Crosby Lockwood & Son, 7, Stationers' Hall Court, Ludgate Hill.

The rapid strides made in recent years in the perfecting of the Diamond Drill and its general use in prospecting for mineral and metalliferous deposits have created a distinct want in technical literature which it is the aim of this little volume to fulfil. Much information has been included to make the work more particularly adapted to the needs of South African diamond drillers and other persons interested in diamond drilling machines in connection with the prospecting or exploitation of mineral lands in South Africa. Full particulars concerning the construction and methods of operating the various drills and special tools connected therewith are dealt with, while the chapters on the cost of diamond drilling, on the computation of the dip and strike of a formation, and drilling by contract will particularly commend themselves to the practical man.

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